THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

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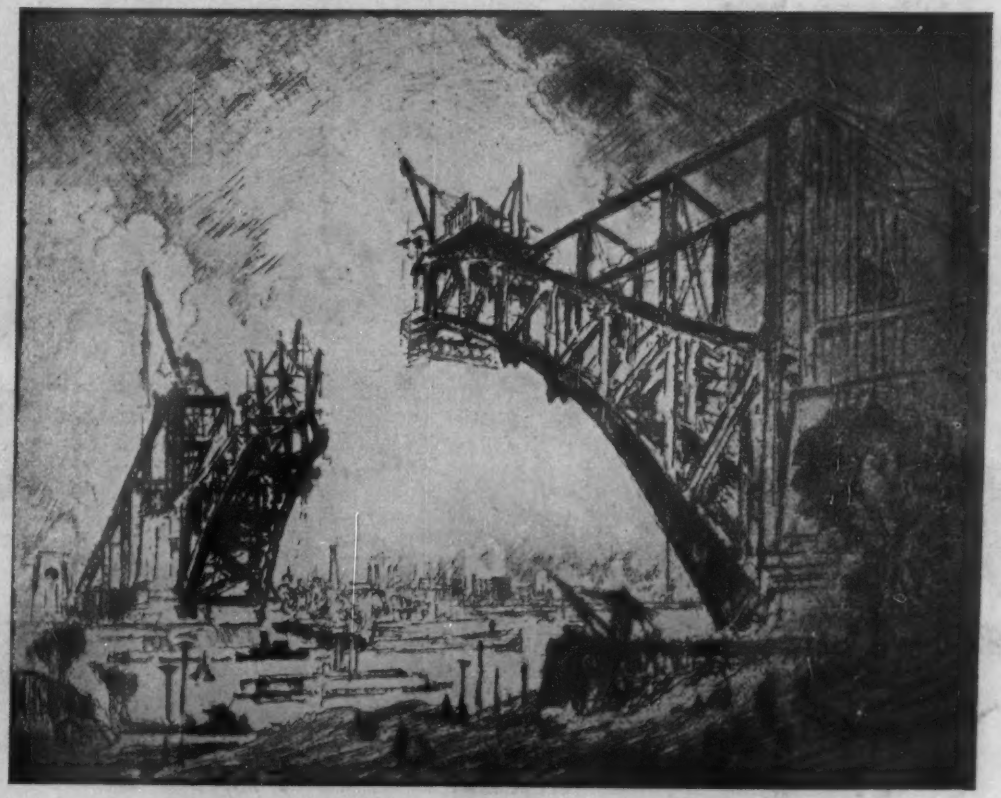

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Lead
is an *Ambitious* metal

WHEN you stop to think about it, this metal, lead, is an astonishing element. It isn't satisfied with taking an essential part in practically every industry, or with protecting buildings against deterioration, or with any number of other jobs of major importance. Lead has one ambition in life—to make itself useful to everybody—and it has succeeded admirably.

In glass, for instance. Ordinary glass is all right for windows and that sort of thing. But it hasn't much refractive power. Scientific and industrial research could not make much progress if instrument lenses were made of ordinary glass. Some method is needed to increase refractive power.

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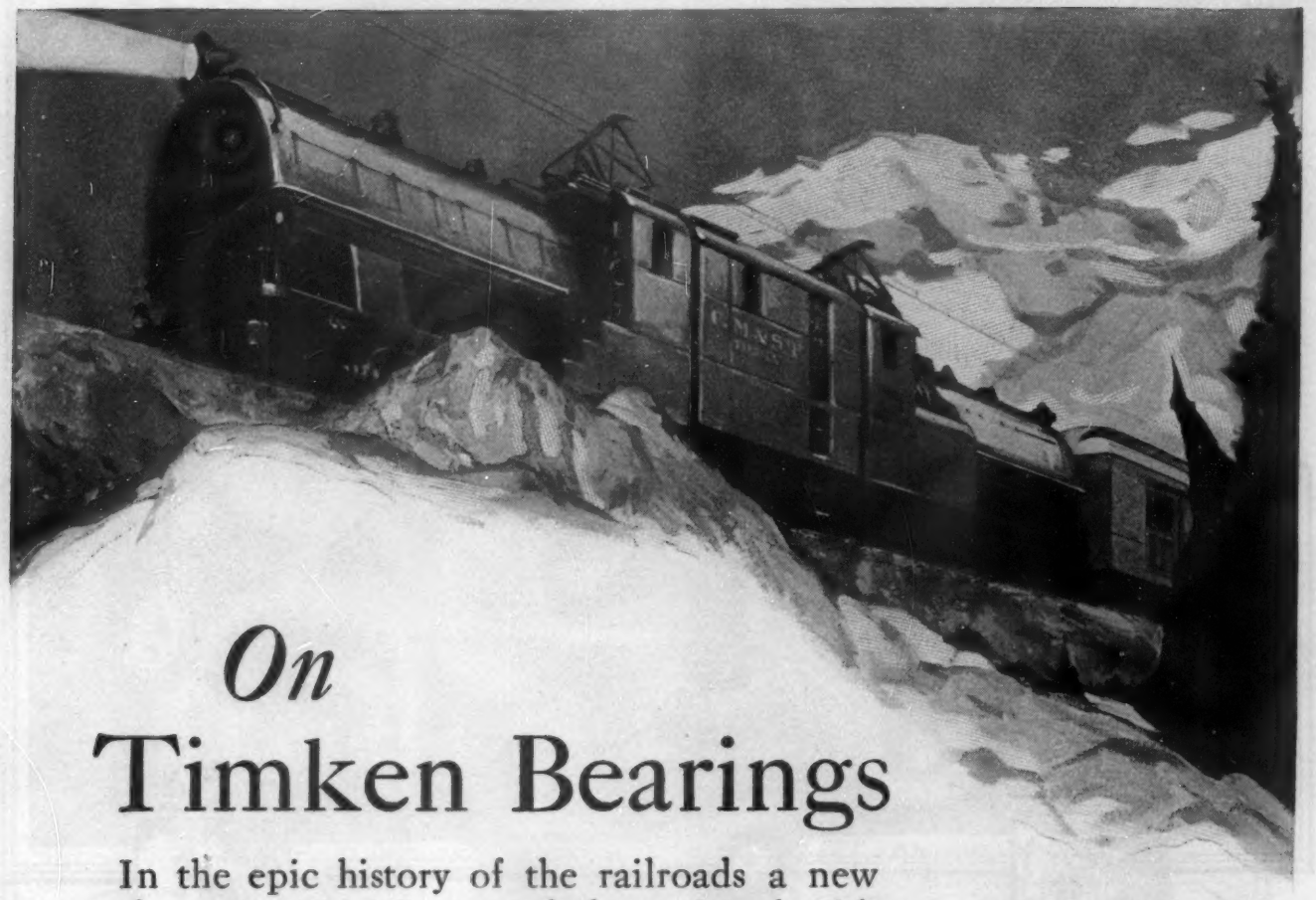

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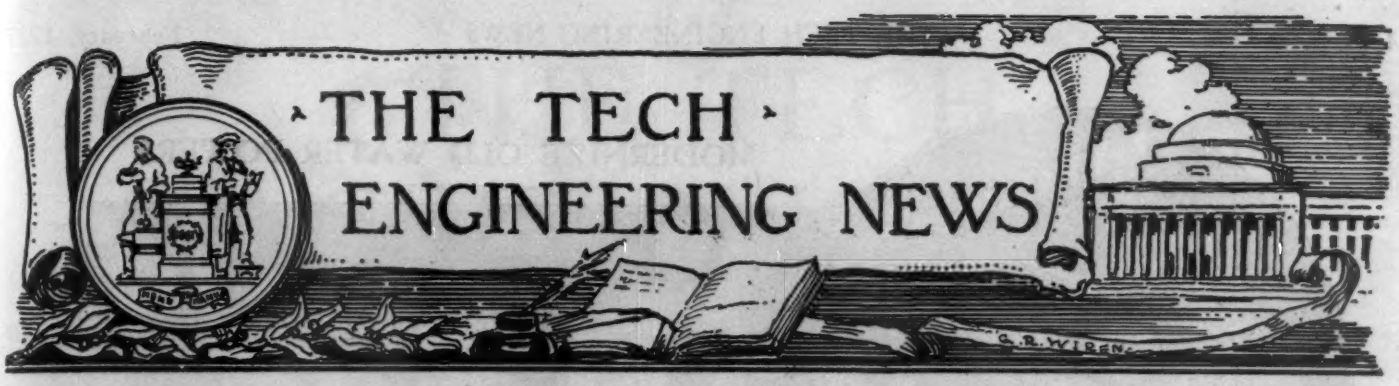

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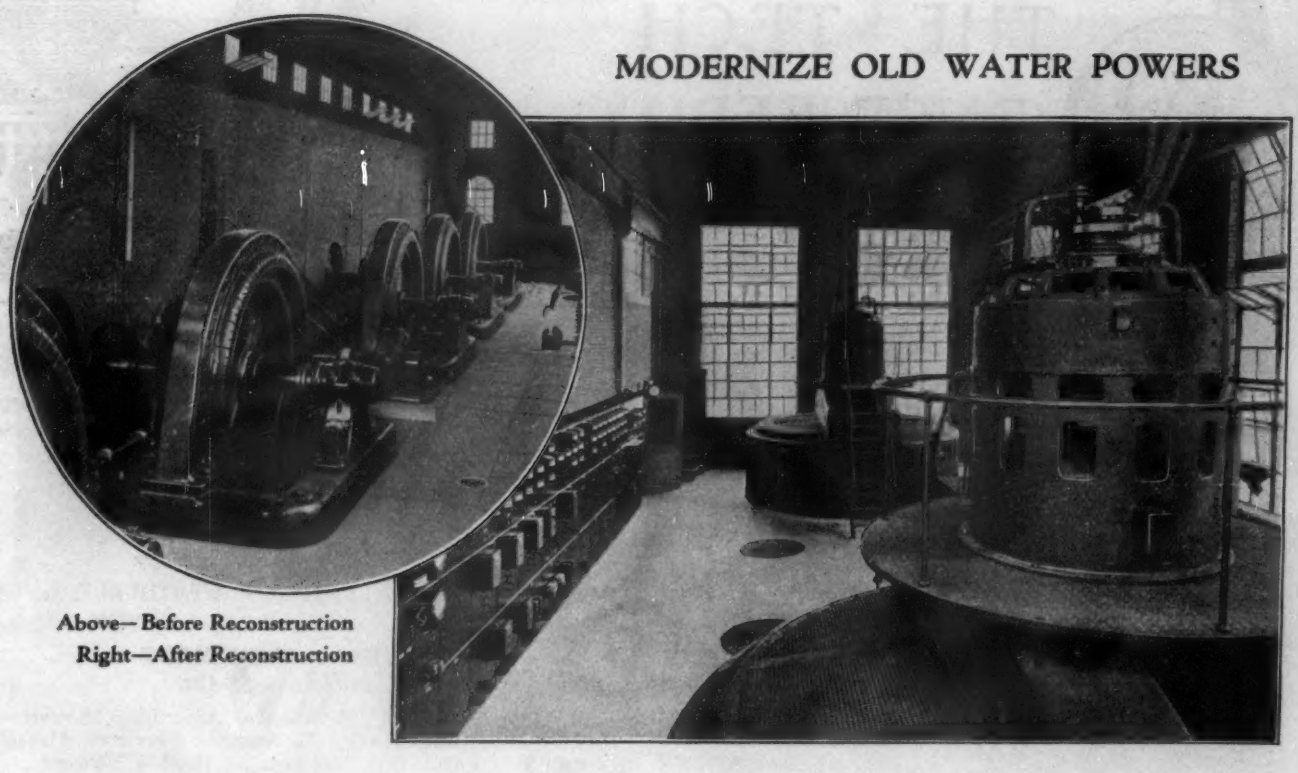
MODERNIZE OLD WATER POWERS



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VOLUME VIII FEBRUARY, 1927 NUMBER 1

Paper Mill Engineering

A survey of the problems in connection with this industry to be solved by the designing engineer

By GEORGE R. WADLEIGH, '97
Manager, Engineering Department, West Virginia Pulp and Paper Company

PAPER appears to have been first manufactured in China, about the year 200 B.C., bamboo being used as the raw material. This paper was, of course, made by hand in limited quantities and small-size sheets. The manufacture found its way westward and the art is known to have been practised by the Arabs about the year 700 A.D.

Continuing its westward march a little to the northward, it reached England about 1500 A.D. It did not reach North America very early in its history, the first authentic mill for its manufacture here being in Delaware in 1804.

From this small beginning it has grown to be the seventh industry of this country, involving an output of about $1,000,000,000 per year.

The mills of this country are located almost always close to ample timber supplies—in all the New England States, New York, Pennsylvania, West Virginia, Ohio, and a few mills in the southern Appalachian region. Another group of mills is to be found in Wisconsin, Northern Michigan, and Minnesota. Since the decline of the forests in the East the industry has taken a jump to Washington and Oregon, using in part refuse from sawmills in that district, and a new growth of mills taking advantage of the natural resources of Louisiana and Mississippi has started in this direction, using southern pine as a basis. Canada has many mills using its spruce forests as raw material.

Essentially, paper consists of cellulose fibres ($C_9H_{10}O_5$) held together and bonded in the sheet by curling and matting and the partial hydroloysis of these same fibres. Hydroloysis is that property which cellulose possesses of dissolving in water if given time enough. The problem in manufacturing the usual opaque papers is to keep the fibres individually as complete as possible, leave them lying in the plane of the paper in diverse directions and uniform thickness, so as to have the strength and opacity uniform, and dissolve or hydrolize just enough to bond together weakening the fibres thereby as little as possible.

There are, of course, as many different methods of carrying out this process as there are different kinds of paper made for different purposes, such as writing, printing, engraving, coating, wrapping, etc. Certain papers have sizing added to effect their qualities.

In papers such as ground wood, Kraft, glassine, etc., other qualities are required; for instance, in ground wood papers used for newspaper and wallpaper cheapness is the first requisite and much material other than cellulose remains in the papers. In the case of glassine papers hydrolization is carried to a high degree, to bring about the transparent condition. Some of the other qualities desired in different papers are: flexibility, waterproofness, special surfaces, special bulk, non-absorption, porosity.

Assuming that one going into manufacture of paper has a knowledge of the process, knows where the necessary leadership can be obtained, and has available a suitable market, there is required, first, a source of cellulose fibre, and second, ample water supply. As additional essentials must be classed labor of the right sort, good freight rates, and low fuel cost.

Almost any cellulose may be made into paper, but for commercial paper manufacture at this date the vast quantity of forms of cellulose fibre possible may be reduced to a very few, which are: rags (cotton and linen), wood, hemp, jute, certain grasses such as esparto, old papers, cotton linters and for certain coarse papers, straw.

In this country from wood is manufactured newsprint, wallpaper, book and magazine paper, certain writing papers, and wrappings. From rags is manufactured high-grade writings, ledgers, and certain low-grade felts, such as roofing felt. From Manila or jute is manufactured heavy wrappings and paper for cement bags; from straw, butcher's papers, straw-board for cartons.

The process may be divided into two sections: First, the preparation of cellulose in the pulp mills; second, the actual making of the paper in the paper mill.

As received, excepting rags and old papers, the raw cellulose fibres (wood, straw, etc.), actually pure white, are bound together by various gums, etc., known as inter-cellular matter, which greatly discolors the bundles of fibres. These bundles of fibres must be separated by mechanical or chemical means, and for white papers virtually all of the inter-cellular matter removed. This at once divides the pulp industry into three classes: mechanical pulp, chemical pulp, and pulp-making from rags.

(Continued on page 26)

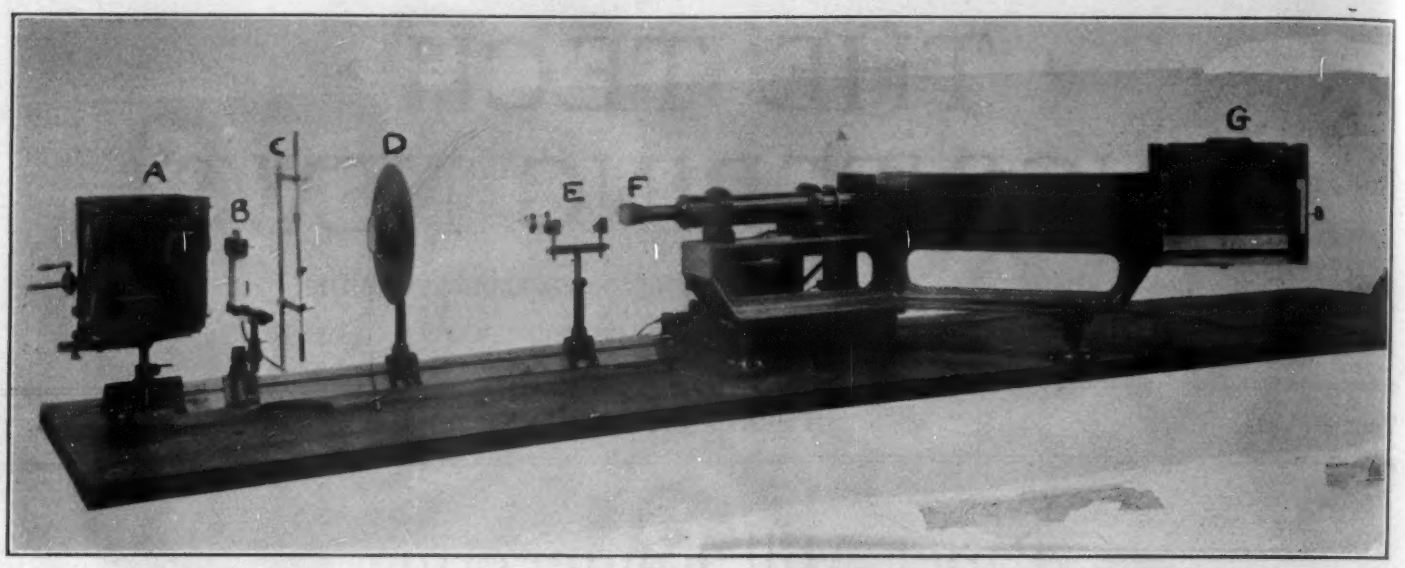


Fig. 1. SPECTROGRAPH AND ACCESSORIES
A Under-water spark as source of continuous ultraviolet light. *B* Spark Gap. *C* Arc. *D* Quartz lens. *E* Quartz absorption cell. *F* Slit of spectrograph. *G* Plate end of spectrograph.

Industrial Applications of the Spectrograph

The spectrograph is rapidly gaining a wider recognition of its industrial usefulness

By HENRY G. DE LASZLO
Research Associate, Department of Physics, Massachusetts Institute of Technology

SPECTROSCOPY is a branch of science which has for its object the investigation of spectra, which may be regarded as the product of the resolution of composite luminous radiations into their homogenous components. In 1661 Newton noticed that when a beam of white light falls onto a glass prism, it is split up into a rainbow-like band of colors ranging from red to violet and covering an area many times that of the original beam. The violet end suffers greater deviation from its original path than the red, owing to the refractive index of glass being higher for the former than for the latter. The spectrograph which performs this service may be regarded as a harmonic analysing engine which reduces the composite curve for radiation from a source of light to a number of pure sine curves, each curve representing light of a specified wave-length.

Light may be regarded as a form of wave motion, and if the light be pure or monochromatic we can define it by the wave length of the ether vibration which produces it. The unit used is the Angstrom (10-8cm)A. Wave lengths in the visible spectrum range from 3000 A (violet) to 7600 A (red), but the spectrum extends on either side of this region, and into the infra-red and ultra-violet. In considering the applications to be mentioned in this article, we only use the range from 7000 A—2000 A (ultra-violet).

The spectrograph which is our modern analysing instrument is shown diagramatically in figure 4., and consists of a fine slit, S, which is illuminated by light from the source, O, focused with the aid of the lens, L. C is a collimating lens, which, being focused on the slit, projects a parallel beam of light on the face of the prism P. F is the photographic lens, and serves to focus all the deviated beams upon the plate Z. Since we wish to investigate the whole spectrum from red to the extreme ultra-violet, it is obvious that we must use for the optical parts a material which is transparent to these radiations. Natural rock-crystal, or quartz, fulfils this condition, and is therefore used to construct the lenses and prism. Now, the most distinctive and sensitive spectral lines lie in the ultra-violet, which is invisible to the eye, and can therefore only be investigated with the aid of a photographic plate, while even for the visible range, a photographic record is far superior, as it can be kept permanently, and is easier to handle for purposes of identification of spectrum lines. Figure 1 shows a complete set up for photographing all kinds of spectra.

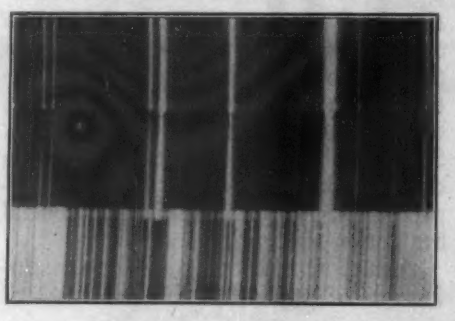


Fig. 2. (Top) Spark Spectrum of pure silver. (Middle) Spectrum of silver alloy with 1% Platinum. (Bottom) Standard iron spectrum.

The application of the spectrograph depend on either (I) photographing the *emission spectra* of the light radiated by various substances under different conditions, or (II) in the case of transparent solids or solutions, determining the *absorption spectra,* or the wavelengths of light absorbed and the percentage of each wavelength cut off.

Emission Spectra

Since each element has a characteristic emission spectrum, if we photograph the light from, say, an arc between two pieces of an unknown metal, or from an arc between carbon electrodes on one of which the unknown material has been placed, and examine the spectrum, we will be able to tell at a glance what the metal is by the position of the spectrum lines. In order to determine this position,

we require a standard, and for this purpose the light from a spark between iron electrodes is usually used, for the wavelengths of all the lines in this spectrum have been determined with great care. We have but to photograph the unknown source in juxtaposition with the iron spectrum to enable us to measure the wavelength of the new lines by interpolation between two known iron lines. Then, by referring to published lists of spectrum lines we can see at once which elements are giving rise to the lines. The analytical chemist would find the method useful, for by dissolving an unknown substance in acid, and photographing a spark between a gold electrode and the solution with the spectrograph, the results would show what metals were present, and the analyst would then be able to plan his line of attack, and could also check up the purity of each precipitate as the analysis proceeds. Specific cases of the use of the spectrograph in analysis will be described later.

Absorption Spectra

Every transparent substance, whether it be liquid, solid, or gas, will absorb light of certain wavelengths. Thus red glass absorbs all the blue and ultra-violet spectrum, while ordinary window glass lets through all the visible rays, but cuts off all the ultra-violet, and quartz is transparent to almost the entire range of wavelengths used in spectroscopy. All organic substances which appear white when dissolved in a solvent transparent to light of all wavelengths, such as hexane, alcohol, or ether, are found to possess a characteristic absorption in the ultra-violet. Thus by measuring the absorption spectra of a body quantitatively, we have an excellent means of identification, since each substance has its own characteristic curve. Fig. 3 shows part of the absorption spectrum of fluorbenzene vapour. At present this method has been but little used in industry, but later we will mention a few of the possible applications.

Industries in which the Spectrograph might advantageously be employed.

Metallurgy

The spectrograph could be used to a considerable extent by the metallurgist, for alloys may have their composition quickly determined, and a control may be kept on the composition of successive batches of alloy made up for a certain purpose, for any variation in composition will at once show on the spectrum obtained. Figure 2 shows the spectrum of pure silver compared with that of an alloy of silver with 1% platinum, which shows the additional lines due to this element. Special steels are now very largely employed in nearly every industry, and the spectrograph permits of a rapid sorting of the various kinds, thus preventing grave errors by using the wrong kind for a specified operation. The spectrograph can give irrefutable evidence of the presence or absence of such alloying elements as nickel, chromium, tungsten, vanadium or titanium. The spark spectrum of pure iron shows a difference when compared with that of a special steel containing 5% chromium. Impurities in raw materials will often cause great loss owing to the spoiling of the finished product. Thus, if copper wire is found to be of low conductivity, it may be traced back to minute amounts of arsenic, antimony, or nickel in the raw metal. Bismuth has been found in amounts not greater than a few thousandths of one percent in zinc and certain alloys, where it causes great harm. Aluminum is rendered less ductile if even a trace of gallium be present, while the complete absence of aluminum is important in bronze castings which must withstand high pressures, as little as 0.01% being deleterious. The Bureau of Standards has used the spectrograph as a method of identifying undesirable impurities such as lead, zinc, copper, or iron in tin boiler plugs. 0.004-2.0% of lead can be easily determined in copper or silver, and the purity of platinum for thermocouples can quickly be ascertained. It is especially in the detection and estimation of small quantities of impurities that the spectrograph is of use, for the alternative chemical methods of analysis are usually very long and tedious. Indeed metallurgy has neglected this valuable aid far too much in the past. A vast field is open here for industrial laboratories to improve their analytical methods and keep a more rigid control on their products.

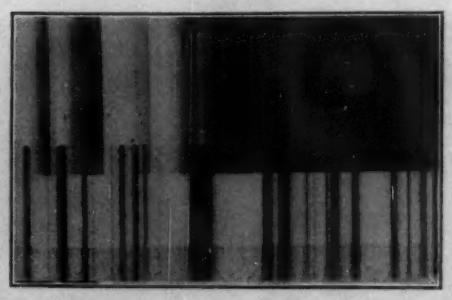


Fig. 3. (Top) Absorption spectrum of Fluorbenzene vapour, (C_6H_5F.) (Bottom) Standard Iron Spectrum.

Mining

The spectrograph allows of a rapid analysis of metals present in any ore by placing the powdered mineral on a pure carbon rod and striking an arc. The arc lines are then photographed and identified. Only a very small sample is required, and the plate forms a permanent record which may even be used as testimony in litigation.

Agriculture

A knowledge of the elements present in the soil and in the ashes of plants can be of great assistance in deciding what crops would be most profitable to grow in a certain locality. The mineral contents of springs and other water supplies are an important factor in agriculture and town planning.

Fats and Oils

In the modern fat hardening process by hydrogenation the catalyst sometimes remains to an appreciable extent in the hardened product. This may be very deleterious to the consumer. The spectrograph will at once reveal small traces of zinc, nickel or other foreign elements present. Similarly traces of poison in canned foods could be determined.

Illumination

Illumination is now becoming a very important industry so it is therefore of importance to know the amount and kind of light that a certain form of illuminant will give. This the spectrograph reveals in a single exposure. Photographic plates

(Continued on page 32)

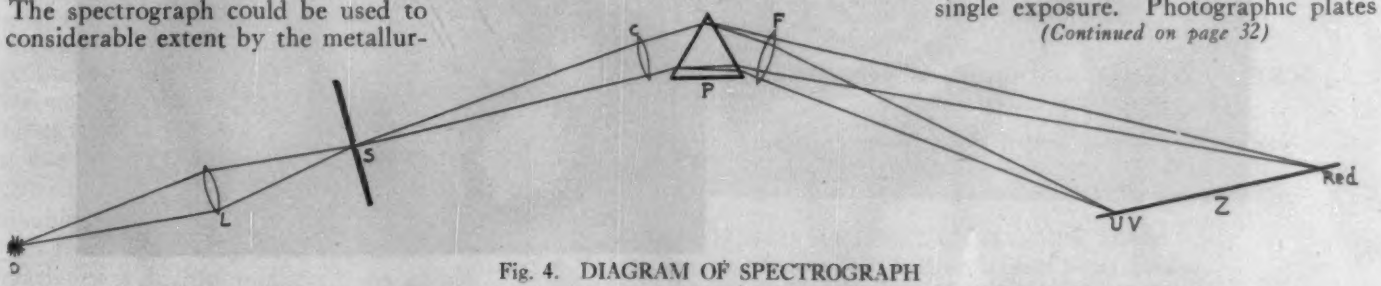


Fig. 4. DIAGRAM OF SPECTROGRAPH

O Light Source. *L* Focusing Lens. *S* Slit. *C* Collimating Lens. *P* Prism. *F* Photographic Lens. *Z* Photographic Plate.

Stellite

A new alloy having a remarkable and valuable combination of characteristics

By A. V. Harris
District Sales Manager, Haynes Stellite Co.

ONE of the greatest needs of modern industry, in its fight for uninterrupted production and increased efficiency, has always been for a metal which would resist wear, abrasion and chemical action at high temperature and under adverse conditions. Recently these desires have been splendidly answered by a metal marketed under the name of "Stellite."

This metal is not in any sense of the word a steel, being an alloy of cobalt, chromium, and tungsten, with any iron present only as an impurity. Due to the high and uniform heat obtainable in an electric furnace and the fact that it is possible to secure a uniform product of practically no adulteration, this method is used exclusively in the manufacture of Stellite. The component metals are charged into the furnace in the right proportions and processed, great care being taken that the resultant product is up to high standards by frequent tests during the melting. The melt can then be cast in any form, in moulds of special composition, after which it cannot be formed by machining or filing but only by grinding due to its inherent hardness.

This is truly a unique metal in that it possesses more of the desirable characteristics than any one other metal of the ferrous or non-ferrous families, commonly used for similar purposes. Stellite's hardness is inherent, requiring no tempering or heat treating. It can repeatedly be brought up to a point very closely approaching its melting point and still retain its toughness and hardness. Frequent or continuous heating and cooling do not have any annealing effect on it. At this point it is important to realize that there is a vast difference between hardness and resistance to abrasion. Although it is possible to temper and heat treat various steels and other alloy metals to a higher Scleroscope or Brinnel hardness, yet Stellite will outwear them at least three to one.

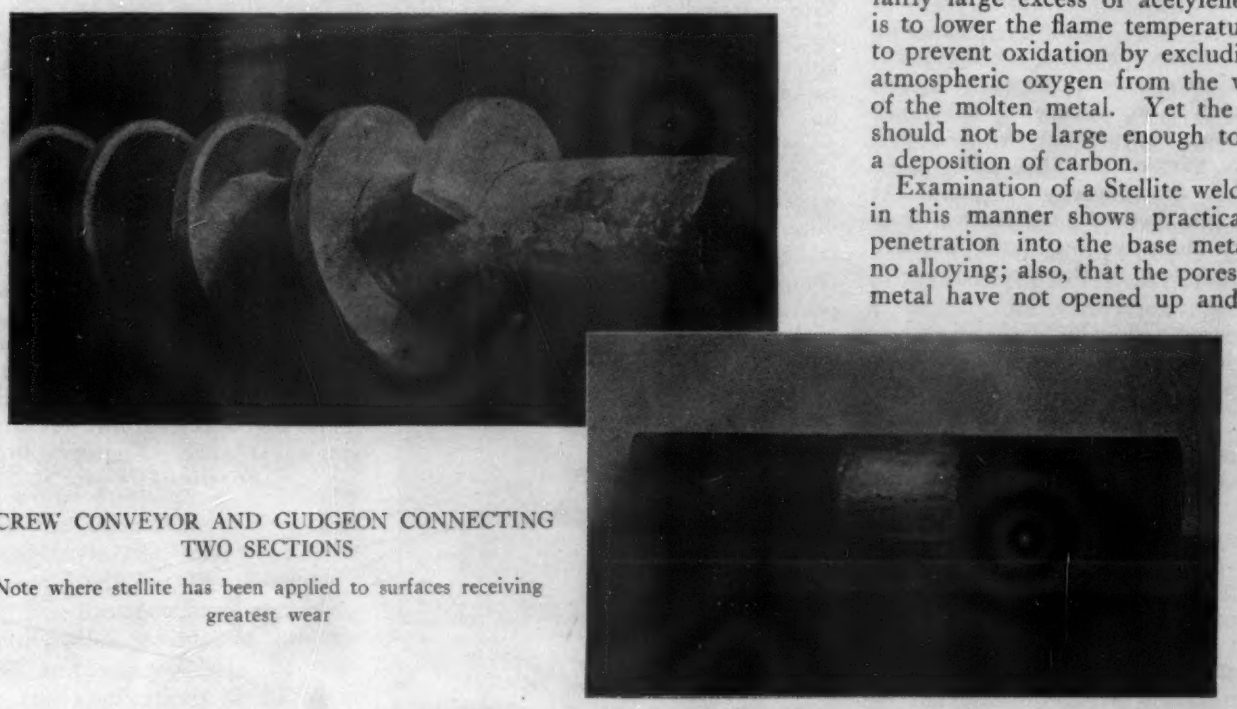
Stellite is also highly resistant to the action of practically all commercial and industrial acids and suffers little or no loss in weight even after being in contact with them over long periods. It is non-magnetic, will take a high and lasting polish, and has an electrical and thermal conductivity equal to about 1.5 per cent that of copper.

What is probably the most valuable and important characteristic of Stellite is the fact that it is possible to melt the metal by means of the oxy-acetylene torch, fuse it to all grades of steel and practically all of cast iron, and have without any heat treatment a resultant surface which still retains all of the desirable properties of the alloy. In this way it is possible to affect the combination of the desirable properties of both metals; the greater tensile strength of the steel base and the permanently hard wearing surface of the other.

Stelliting, as the process is called, is not a weld in the true sense of the word nor is it a braze. In welding a neutral flame is used and the surface of the base metal is brought up to a melted and flowing condition, where the filler rod is puddled and alloyed with the base metal. On the other hand a braze calls for sufficient heating only to open the pores of the base metal, after which the bronze or brass is flowed on and the only bond is that which is obtained by the bronze or brass penetrating into the pores and holding on. The Stelliting process requires that, after preheating the part, the surface of the base metal upon which the Stellite is to be applied be brought up to a heat where it just begins to sweat and has an oily appearance. Then without using a flux, the surface is tinned by melting the Stellite from the rod and allowing it to flow onto the base metal forming a thin layer. In this process precautions are taken to obtain the lightest possible penetration into the parent metal in order to eliminate the possibility of any alloying with the Stellite because this would detract from the desired qualities of the surface. After this the alloy should be flowed onto the tinned surface, with as little agitation as possible in order to prevent blow holes, until the desired thickness is obtained.

The flame used should contain a fairly large excess of acetylene. This is to lower the flame temperature and to prevent oxidation by excluding the atmospheric oxygen from the vicinity of the molten metal. Yet the excess should not be large enough to cause a deposition of carbon.

Examination of a Stellite weld made in this manner shows practically no penetration into the base metal and no alloying; also, that the pores of the metal have not opened up and taken



SCREW CONVEYOR AND GUDGEON CONNECTING TWO SECTIONS

Note where stellite has been applied to surfaces receiving greatest wear

WEARER PLATES ON ROLL CRUSHERS
Insert shows stellited edge which increases life an average of four times

hold. In other words, it is not a true weld nor is it a braze, but apparently a cross between the two.

It is also important to note that the melting points and the coefficients of thermal expansion for Stellite and steel are almost identical; which fact facilitates the welding operation, and minimizes the danger of the Stellited surface cracking upon cooling or during any operation which involves extreme fluctuations of temperature.

All grades of carbon and alloy steel can be Stellited as well as most surfacing bronzes or brasses, but a fairly good bond is possible with copper should the occasion arise. It is also possible to replace the oxy-acetylene torch by a carbon or metallic arc, but the almost universal practice is to use the oxy-acetylene process because the resultant surface is cleaner, less porous, and unalloyed.

Due to the fact that Stellite has so many characteristics, we will state each in detail. Now take for instance, a combination of the two properties, resistance to heat and abrasion, which are very forcibly seen in the use of Stellite on hot drawing and hot forming dies. The die is called upon to resist the heat of the metal being formed and also the abrasion of this metal being drawn for the die surface. Various plants throughout the country are now using Stellite surfaced dies on these particular applications and as a general rule are getting three to five times the life they formerly secured from the best tool steels obtainable.

In the hot forming of sheet metal invariably a highly tempered die of carbon or alloyed steel is used, the temper being called upon to resist the heat as well as the abrasion. It does not take long until the heat of the forming operation has drawn the temper up to a point where the metal has begun to soften. When this occurs it is necessary to cool the die, remachine or grind and temper again, this procedure being carried through until the die is worn down to a point where it is scrapped and it is then necessary to make new dies. Stellite is very desirable on applications of this type as it will resist the heat without losing any of its hardness. A die of the common machine steel or carbon steel is made up in the usual manner and the surface which will come in contact with the heat and be subjected to abrasion is left approximately 3/16" under size to allow for the building up with Stellite.

After a die has been Stellited and ground to size it will stand up under the application which calls for the metal to resist heat and still retain its hardness. For instance, in the making of automobile crank shafts which are forged to a very close limit, in which process a flash is left on the forging, it is necessary to trim this flash off while the metal is still in a hot condition. Dies made of various steels and alloys have been employed in the making of these trimming dies and even though they do give as high as 2000 pieces before the die needs reworking, they are still very inefficient as compared to a Stellite die. It is only necessary to Stellite the portion on the trimming die which is subjected to heat, namely, the edge. This die will stand up and has stood up under as many as ten and twelve thousand operations before requiring reworking. It is then only necessary to return the die to the welder to be re-Stellited and then ground, no tempering being necessary. The only way a Stellited die ever approaches the scrap stage is when it becomes broken. Otherwise its life is indefinite. Trimming dies of this type will give from 4 to 6 times the number of pieces that the best steels can. Other applications where it is necessary to have resistance to heat is on forming dies for automobile spring clips, railroad anchors and numerous other fairly heavy steel sections which require hot forming or shaping.

(Continued on page 42)

STELLITED HAMMERS ON HAMMER MILLS
1. New steel hammer. 2. Stellited hammer before grinding. 3. Ground stellited hammer. 4. Stellited hammer after 92 hours of use. Steel lasts 14 hours.

Marine Fire Protection

The combination of a fire detection system with an extinguishing system has proved effective in reducing the fire hazard to shipping

By T. J. KAUFFELD
Engineer, Walter Kidde & Company, Inc., New York

FIRE is one of the most appalling of mankind's terrors. This hazard is serious enough when encountered upon land, but the alarm at sea strikes terror to even the most courageous. With a fire raging in an inaccessible compartment and no means of ascertaining its scope or progress, a ship is practically helpless.

The problem of fire prevention and fire protection resolves itself into preventing the outbreak and serious spread of fire—the latter of which is dependent upon means for prompt detecting and extinguishing. It is apparent that the surest and most effective way to put out fire is to apply the extinguishing medium when the combustion begins.

The fire danger in inaccessible spaces aboard ship has long been recognized. For combating such fires, experience has demonstrated that high pressure steam and carbon dioxide are the two most effective mediums. With the use of water, cargo is unnecessarily ruined and in the vast majority of cases it is impossible to direct it on the burning material. Flooding of the compartment seriously affects the stability of the ship. It can readily be seen, therefore, that water as an extinguishing agent aboard ship has a greatly restricted use.

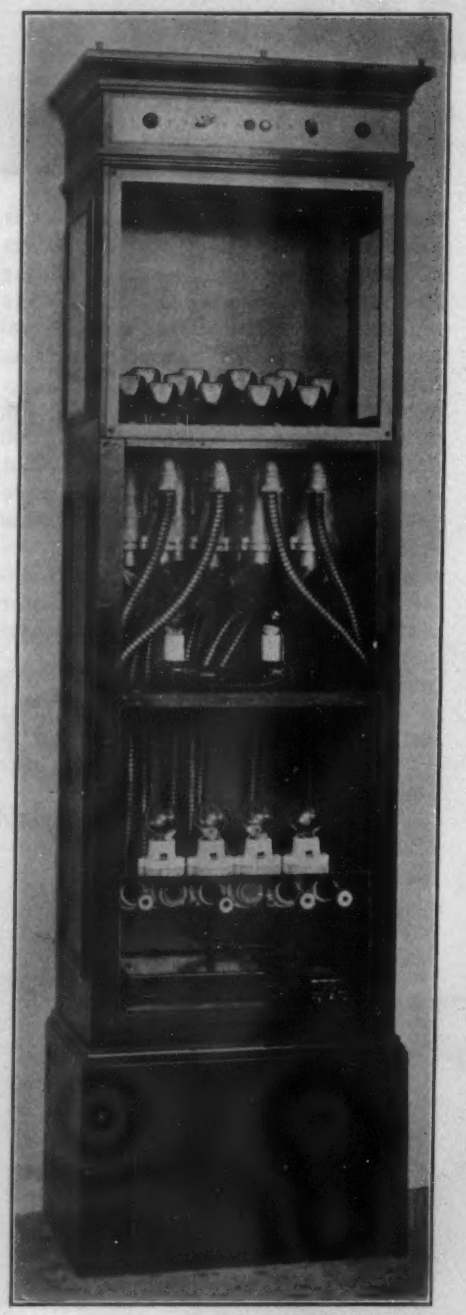
Steam, potentially the same as water, does not damage the cargo to as great an extent as the latter. The main advantage in the use of steam lies in the fact that it is easily directed to the fire and surrounds the same with an incombustible blanket.

In late years the trend in marine fire extinguishing practice has been the adoption of carbon dioxide, a medium combining the extinguishing properties of steam with the ideal so hard formerly to accomplish, namely, confining fire loss to loss by fire.

Causes of Marine Fires

Marine fires originate from a great variety of causes. The breaking of fuel oil pipes, inflammable vapors, spontaneous combustion in cargo, lamps and rodents cause many of the fires. Other fires originate through the carelessness of the stevedores and crew in regard to smoking. Some of these causes can be eliminated by special precaution, the human element will always remain.

Regarding the practice of loading cargo, a mere allusion will suffice. Cargo is loaded high on wharves and packed into every available space aboard ship by unskilled labor. Included under this general heading "Cargo" comes freight of every description, some of which is combustible. Through carelessness of the stevedores, a spark of fire may be dropped. Smouldering in the contents of a bale or other package results, and the process of active combustion is begun.



RICH DETECTING CABINET
Front removed to show lighting arrangement

After loading is finished, these inaccessible compartments are battened down one upon the other so that it is later impossible to gain access to them without first shifting the cargo.

The Rich System of Cargo Fire Detection

The Rich System of smoke detection consists of a series of pipes radiating to all parts of the ship thru which air samples are continuously drawn from every cargo hold or closed compartment and conveyed to the wheel house where they terminate in a chamber under partial vacuum produced by exhausters installed in duplicate on roof of wheel house. This vacuum chamber forms a part of the detecting cabinet which is of steel, with a handsome grained finish. An ingenious lighting arrangement has made this a highly sensitive apparatus for detecting the slightest particle of smoke.

Powerful beams of light are projected through the ends of the pipe terminating in the cabinet. The slightest particle of smoke flowing through this beam of light acts as a reflecting medium and immediately attracts attention. The source of the lighting arrangement is entirely concealed and beams of light are projected against a black absorbing surface. By this arrangement there is no disturbing light to hinder navigation. Each pipe terminating in the vacuum chamber ends in a small metallic flare which is marked and numbered to correspond with the hold or cargo compartment to which it runs.

The terminations of the pipes in the various holds are capped by smoke accumulators protected from obstruction by rodents with screens. Immediately upon production, the first smoke curls from the seat of combustion and into the current of air leading to, and produced by the smoke accumulator. From this point the smoke is conveyed by the piping to the wheel house where it makes its appearance in one of the flares in the detecting cabinet. This gives an instantaneous indication as to where smoke is coming from.

The superiority of the Rich System of smoke detecting is illustrated in the main by the fact that the detecting fire lines may also be used to convey

the extinguishing medium to the compartment on fire. This is accomplished by the insertion of a special Lux-Rich Three-way valve at some conveniently located and accessible point in the detecting lines. These valves are grouped together in a steel cabinet located as directed for facility in operation.

By a novel and unique arrangement an unobstructed way is provided through these valves for the continuous air samples coming from the various holds on their way to the detecting cabinet. It is only in case of fire that the continuity of the line from the valve to the detecting cabinet is shut off and the third port opened, thereby allowing the extinguishing medium to flow through the former detecting lines to the space on fire.

After a sufficient amount of the extinguishing medium has been injected the detecting line can be again established merely by the reversal of the above operation and without the necessity of replacing any portion of the apparatus. Other systems require repair after the first alarm has been given.

During the extinguishing period in one of the Rich lines, all others give uninterrupted detection service.

The Lux System of Fire Extinguishing

Tremendous strides have been made in the last few years in the development and perfection of apparatus for fire extinguishing. The ideal extinguisher sought after must be absolutely reliable, rapid in its extinguishing effects and non-injurious to the materials with which it comes in contact. Engineers have finally been forced to acknowledge the application of inert gasses, realizing that in an inert gas lies the only hope of an extinguisher that will be harmless in itself, and yet be reliable and positive in its extinguishing effect.

Sulphur Dioxide in cylinders has an economical disadvantage of being expensive, moreover, this agent is not always obtainable in the liquid form. Sulphur Dioxide is also a bleaching agent, is corrosive and is deadly to human life.

When oxygen is manufactured by the liquid air process a large amount of nitrogen is obtained as a by-product. Due to the ratio of cylinder or shipping weight to the weight of the volume of gas contained, an extinguishing apparatus employing this medium would be almost prohibitive due to the size and weight of equipment required.

Flue Gas presents the disadvantage of having oxygen among its constituents and is therefore not wholly effective. Damage to cargo from sulphur or other impurities will result unless flue gas is purified.

The Lux Principle

The effectiveness of carbon dioxide as a fire extinguishing agent has been known for years. This dry gas has been used as a constituent in almost every chemical extinguisher whether of the soda-acid, foam, or other type. Utilization of the pure carbon dioxide has been made a commercial possibility by the employment of the Lux principle, which discharges the liquid carbon dioxide from the container by means of a syphon tube extending from the valve to a point at or near the bottom of the container.

Any quantity of carbon dioxide can be released by Lux within a few seconds. There will be absolutely no freezing, no stoppage and full discharge of stored volume will result. This latter is accomplished by special design of release valves and expansion nozzles.

The fact that carbon dioxide penetrates in all cracks and crevices of the space protected and works in three dimensions instead of two, makes it possible for Lux to extinguish fires in closed or partially enclosed spaces where a direct application extinguisher could not hope to reach. The principle of effect of carbon dioxide is the dilution of the oxygen content of the atmosphere rather than cooling and quenching the burning material below its ignition temperature.

Steel cylinders as employed in the Lux System are tested for strength and each is fitted with a special Lux valve having a device which operates to release the gas when its temperature reaches 130 degrees F. and the pressure reaches an undesired point.

Due to the large ratio of expansion of the carbon dioxide when released it is possible to protect a large space with a relatively small equipment. Lux operates by having liquid carbon dioxide stored in steel cylinders ejected into a pipe line through which it is conveyed to the space on fire. Upon reaching its destination the carbon dioxide expands and changes over at once into the gaseous form.

Conclusion

Installation of a fire detecting and extinguishing system such as is illustrated by Lux-Rich, is an example of adequate fire detecting and extinguishing methods which are finding great favor in not only protecting motor ships but for coping with similar hazards on oil burning or coal burning steamships.

CYLINDER ROOM ON S. S. "LEO"

The batteries of cylinders manifolded together for rapid discharge of liquid carbon dioxide are shown

Problems of Steam Turbine Design

An interesting account of some of the difficulties which are met and have to be solved in the design and construction of steam turbines

By Haus Dahlstrand
Engineer-in-charge, Steam Turbine Dept., Allis-Chalmers Mfg. Co.

THE increase in steam temperatures and pressures, the adoption of new cycles of operation, and the increase in sizes of steam turbine generating units for steam power plants has necessitated radical changes in the detail design of steam turbine units as well as the adoption of new special materials more suitable for the new conditions. It is the intention of this paper to deal briefly with some of these problems in the detail design of steam turbine units.

Turbine Cylinder

The steam turbine cylinder, being exposed to the extreme high temperatures and pressures at the high pressure end and at low temperatures at the exhaust end, must on account of these conditions be carefully designed in order to minimize the distortion due to the extreme differences in temperatures. It must also be designed so that any sudden changes in temperature will cause no distortion that will in any way endanger the operation of the turbine unit. It is obvious, therefore, that the distribution of metal in the walls and flanges should be such that an even expansion will take place under all conditions. The cylinder is split horizontally and equipped with heavy flanges through which the two cylinder halves are bolted together. It is obvious that in this part of the structure, the difficulties from expansion will be the greatest and, therefore, it is important to design the flanges so that when cylinder is bolted together a sufficiently high unit pressure exists between the two metal surfaces to prevent steam leakage and at the same time permit enough flexibility in the walls so that the bolting will keep the flanges absolutely tight during changing temperature.

For High Pressure and Temperature Conditions

The high pressure part of the steam turbine cylinder is made of special high-grade carbon steel casting. Special methods have been developed for the careful heat-treating and annealing of the castings so that the material shall be of uniform structure throughout. This is done for the purpose of increasing the strength as well as making the casting more suitable for extreme temperature changes. Careful checking and inspection of the casting is essential during the various stages of manufacture in order to insure a uniform and suitable structure.

Turbine Spindle

The turbine spindle, being exposed to the same temperatures as the turbine cylinder must also be carefully designed so that no distortion will occur from temperature changes. Other requirements are that the stresses are kept within safe limits for the material used and that the critical speed be kept away from the normal running speed. In the high pressure part of the spindle the diameters are generally small and consequently the centrifugal stresses do not require any special consideration. In the low pressure end, however, the centrifugal stresses are generally very high, particularly on large turbines, and therefore that part of the spindle requires a careful study in order to keep these stresses within safe limits and at the same time get, as far as possible, an even distribution of stresses. Generally the low pressure end of the spindle is designed with discs or rings mounted on the spindle shaft. The fit between the rings or discs and the shaft must be such that when the turbine spindle is rotating at its normal speed, they will still be tight, even if some temperature difference should exist between the two parts.

With reference to the critical speed, it is customary to have a turbine shaft operating above or below this speed. However, it is important to keep the critical speed far enough away from the normal running speed so that there will be no vibration set up from this source.

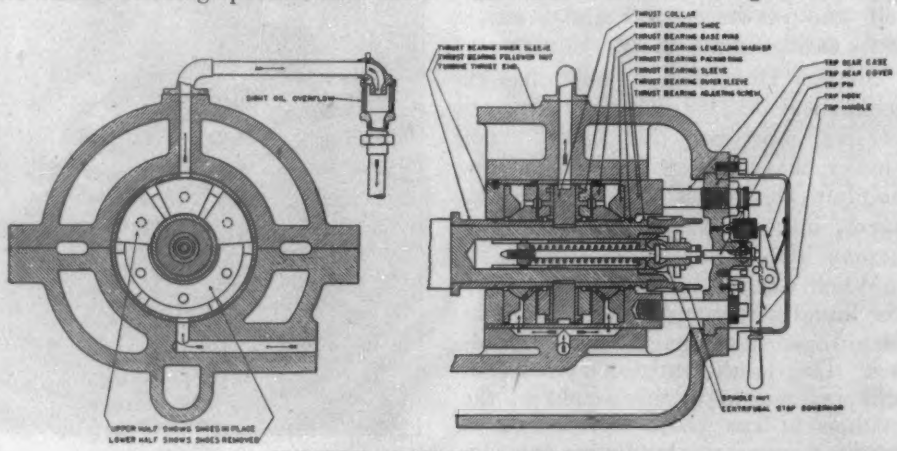
The material used for the spindle is forged steel throughout. The shaft itself is made of high grade carbon steel, fully annealed and manufactured under very rigid specifications. Those parts subjected to high stresses are generally made of some special carbon steel or alloy steel, heat treated in order to increase its strength and make it suitable for the stresses those parts are subjected to.

Blading

The blading, forming the means through which the energy in the steam is transferred into mechanical work by rotating the turbine spindle, forms one of the most important elements in steam turbine construction. The blading has to stand high temperature in the high pressure part of the unit and high stresses in the low pressure part and must also be suitable to withstand corrosion and erosion throughout the whole cycle of expansion.

The design of the blading naturally requires a very careful study throughout the whole turbine in order that the highest possible economy may be obtained with the various cycles of operation. On large units particularly, it is very desirable to make the detail design throughout the whole unit to conform as near as possible to the cycle of operation under which the unit will run in the Power Plant.

The mechanical construction of the blading itself differs considerably, not only in the various types of steam turbines, but also between the high pressure and low pressure sections of the same units. Drawn materials cast into foundation rings mounted in



SPINDLE ADJUSTING BEARING

Adjustable blocks make it possible to aline the shaft both radially and axially

turbine cylinder and spindle are used in some constructions. In others, blades are forged or machined from solid bars to the shape required for the proper mounting in cylinder and spindle.

The material used in steam turbine blading must be suitable for various conditions as mentioned before, and a large amount of experimental and research work has been carried out on different kinds of materials. From the results of this work the suitability of materials now used has been demonstrated. Among materials used at present, the best known are:—monel metal, nickel steel, stainless steel and high-grade chrome nickel steel. Further research work is continually being carried on in order to develop still better materials for use in blading.

All blading materials are also tested for fatigue as it is important that the fatigue limit of the material shall be known in order to keep the stresses from centrifugal force, vibration and the impact of the steam, well within safe limits.

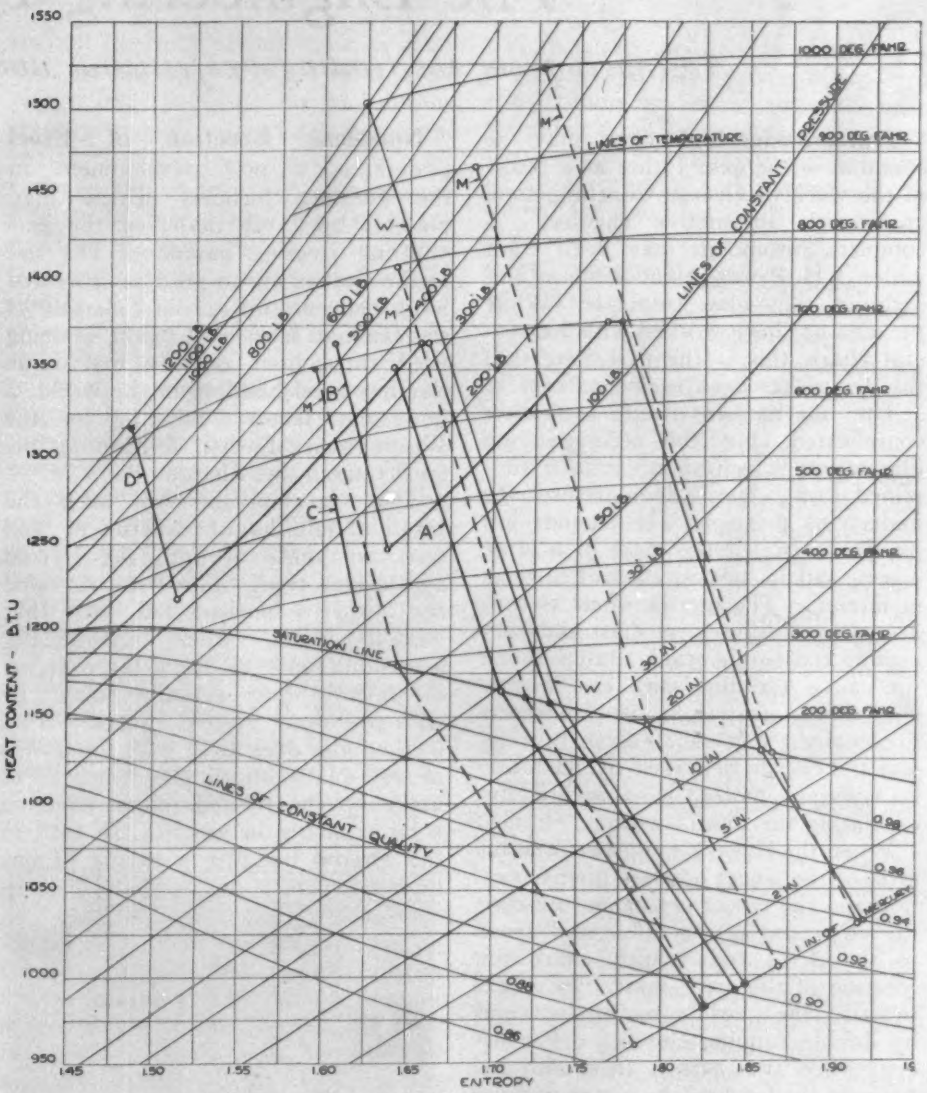
Coupling

Each of the rotating elements on the steam turbine unit is generally carried in two bearings and coupled together by means of a flexible coupling. On large units, on account of the great forces to be transmitted, the coupling must be very carefully designed. Figure No. 1 shows a claw type flexible coupling. From this, it will noted that the coupling claws are lined with plates of a different material than that used in the coupling sleeve. This is done for the purpose of reducing the wear on the surfaces. It is obvious that good lubrication is also required in the various parts of the coupling. All surfaces must be accurately machined and scraped so that the pressure on all the claws is uniform.

While the couplings used are more or less flexible, it is nevertheless of great importance that the rotating shafts be lined up accurately with each other as this will result in a smoother running unit.

There are certain other features required in turbine couplings such as easy disconnection so that one rotating part can be turned over independently of the other, and also in some special cases when it is required to run the generator as a synchronous condenser without running the turbine spindle.

The material used in the coupling is generally high-grade forged steel, specially treated and tested to make sure that same is suitable for the service required of the coupling.



STEAM EXPANSION LINES

Energy available under the expansion line "D" is not nearly so great as that under the line "W." See text page 42

Bearings

With increase in size of steam turbine generating units, the design of the bearings has also become a problem of importance. It is only a very short time since a surface speed of 100′ per second and a bearing pressure of 100 lbs. per square inch was considered quite extreme, whereas now a surface speed up to 150′ per second with a bearing pressure of 140 to 150 lbs. per square inch is being used on the larger turbine generating units.

There have been no particular troubles in this part of equipment and this is presumably due to the fact that the designers have used great care in the construction of the bearings. From the experience gained, it appears that the surface speed on a bearing can be run up to almost any point provided the heat is carried off as fast as it is generated in the bearing and that the temperature is kept within reasonable limits. To accomplish this purpose, the oil, used for lubrication and cooling, should enter the bearing at a reasonably low temperature and should run through grooves well designed so that the oil not only is carried around the shaft for lubrication but also that the excess oil used for cooling is spread over as large a part of the surface of the shaft as possible.

The rotating part in a turbo-generating unit generally requires some radial adjustments in order to compensate for discrepancies in the machining of the various parts and also for the lining up of the separate shafts. To take care of these discrepancies and adjustments, the bearings are generally provided with adjustable blocks on the two sides and on top and bottom of the bearings. Between the blocks and the bearing body, shims are installed which make it easy to move the bearings sideways, upwards or downwards by moving the shims from one block to anoth-

(Continued on page 40)

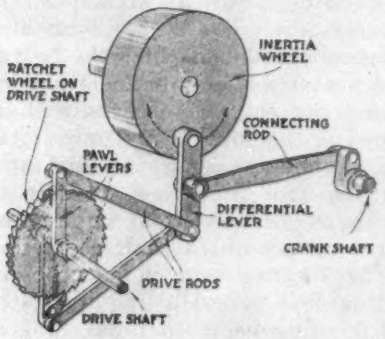
The Engineering Field

Abstracts from the leading professional and trade journals

Transmission-less cars may be common in the near future as a result of the work of George Constaninesco, an English automotive engineer. A complete automobile has been built with a 5 H. P. two cylinder motor embodying this new principle. While the idea has been worked with for several years, this is the first time that the device has been used in a car.

The mechanism itself is rather complicated, but the accompanying illustration, which shows it in a simplified form, clearly demonstrates the underlying principle. It depends upon the inertia of the mass of a large wheel, and its opposition to being set in motion. The inertia wheel is connected by a differential shaft and connecting rod to the crank shaft. When the car is standing with the throttle shut down, its weight on the wheels prevents the drive shaft from turning, and the energy delivered by the slowly running motor is absorbed by oscillating the inertia wheel.

When the throttle is opened, the inertia of the wheel opposes further motion and the power is transmitted thru the other end of the differential lever to the drive rods which cause the rotation of the drive shaft. In actual practice, the pawl levers are replaced by double running clutches. The inertia wheel thus acts as an equilibrant between the force of the motor and the road resistance. Once the car is running, it becomes practically stationary, and all the power is transmitted to the wheels.



(Copyright) Popular Science

VIEW OF 5 H. P., P. I. V. GEAR

There seems to be no limit to the resistance the car can overcome. Hills present little difficulty, as the throttle is simply opened further, and the increased motor speed counteracts the increased road resistance, while troublesome shifting of gears is eliminated. It can be easily seen that a clutch is unnecessary with this device.

Noiseless Erection of Steel girders is a new development in the building business which may possibly spell the doom of the ear-splitting riveting hammer. The use of the electric arc to produce a welded joint between the girders instead of the familiar fabricated union, is being used throughout on the first large rivetless steel building in the world, a five-story factory building for the Westinghouse Electric & Manufacturing Company at Sharon, Pa.

This development has been the result of months of experiment and tests on joints of both the riveted and welded type. This work revealed the hitherto unsuspected fact that welded joints, when scientifically made, not only assure a large factor of safety, but actually may be stronger than riveted joints. This method also does away with thousands of steel plates and angles which go to make up the riveted joints, effecting a large saving in weight. In fact, in the Sharon building a saving of one hundred tons or some 12% is expected.

The arc welding method also has its drawbacks, however. The welded joint, if not properly made, is subject to a number of defects which cannot be detected at a glance. The most common of these defects are gas pockets, seams and cracks in the metal, and the lack of a perfect fusion of the metals.

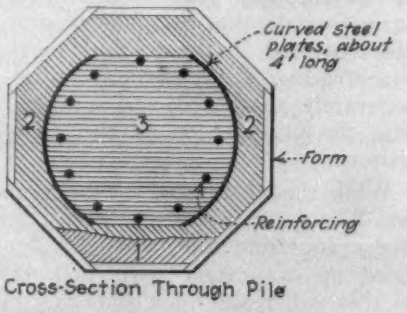
This method of erecting steel buildings requires a new type of skilled steel worker with an expert knowledge of metals and their welded properties. At present, steel workers receive beams punched and fitted for their proper place and all that is necessary is the riveting of the members in place. The men erecting welded steel buildings must also have a thorough knowledge of fitting and assembly in order to carry on their work. This points to the development of a new class of workman skilled with the welding arc who may in time replace the picturesque ironworker with his deafening riveting gun.

Monel-Plymetyl, a new construction material, is a development of the plywood industry. It consists of a panel of plywood faced on one or both sides with thin sheets of monel metal, a non-corrosive alloy of nickel, copper and iron. Thus the strength and lightness of plywood is combined with the resistance to acid, wear, and rust of monel.

Protection of Concrete Piles against deterioration by the action of sea water has long been a problem. At first, piles completely impregnated with asphalt were used, but the loss in strength more than counteracted the longevity and the idea was unsuccessful. Final solution of the problem has been found in the use of a pile having two sections which combine to give the desired results.

A dense mixture is used in the core of the pile to insure strength, while an outer layer contains concrete in the same proportions but is a drier mix, and therefore more porous. Steel plates are used to separate the mixtures and are withdrawn as the concrete rises in the form.

After the pile has cured for two months, the outer layer is treated with asphalt in a simple way. Moisture is driven off by heating the piles to 180 degrees F. and they are then placed in a 23 inch vacuum to insure maximum porosity. Asphalt is then introduced at a temperature of 250 degrees F, and a pressure of 150 lbs. per square inch for eight hours. The piles become impregnated to a depth of 1 1/2 inches which is sufficient to insure complete resistance to the action of brine. Since the strength is but slightly less than that of ordinary concrete pile, these new piles are highly satisfactory, and it is claimed that they are superior to the creosoted piles advocated by many engineers.



Cross-Section Through Pile

(Copyright) Engineering News Record

CREOSOTING CONCRETE PILES

Marine Accidents caused by collisions between ships passing in a fog or storm will be greatly lessened by the use of a new radio invention, which is a low power automatic transmitter sending out a characteristic signal with a range of about ten miles. Installed in the pilot house, it is inde-

pendent of the ship's other radio apparatus. The device is very compact, no larger than the usual cabinet receiving set, and being automatic, it requires no care other than "turning on" and "off" when adverse weather conditions are encountered. The signal transmitted can be heard within a ten mile radius, and by the use of the radio compass or direction finder, an approaching ship can determine the exact location of the vessel equipped with the device.

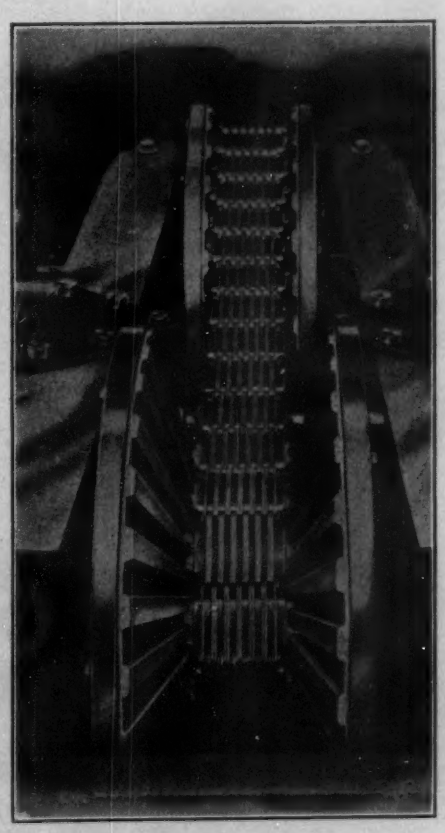
Solid Helium. A short time ago Professor W. H. Keesom of the Leyden University succeeded in solidifying helium gas, which up till then, had withstood all similar attempts. He first tried to condense it in a small brass tube immersed in liquid helium and connected with German silver tubes at both ends. At a pressure of 130 atmospheres, the small tube appeared to be clogged up while at a slightly lower pressure it seemed to be quite free. The same phenomenon was observed at 86 atmospheres pressure with a temperature of 3.2 degrees Centigrade absolute. The same effect with a decreased pressure required a decrease in temperature. A graph was plotted and showed that solid helium should exist at 16 atmospheres and 0 degrees Centigrade absolute. Further tests were made with a more sensitive apparatus, but the exact limits between the solid and liquid helium could not be ascertained.

Variable Power Transmission. The "P. I. V.," or positive drive infinitely variable ratio gear will be a valuable addition to the field of mechanical power transmission. It consists essentially of two expanding pulleys whose opposing surfaces are cones which can be moved back and forth on the shaft; in this way varying the distance between the faces of the pulley. The pulleys are connected by a chain of constant width, and when a pulley of large effective diameter is desired the faces are brought together, but if a smaller pulley is wanted, the faces are moved apart.

The principle of variable pulleys has been well known for some time, but the invention was hardly practical until a method of linking them was devised. The inner surfaces of the pulleys are made to slope in at an angle of 60 degrees, and have a series of alternate ribs and channels radiating from the center and increasing in width as the rim is reached. These are so located that the ribs on one face are opposite the channels of the other.

The driving chain consists of short links, so built as to contain a longitudinal sleeve or casing which is filled with a number of loose thin steel plates free to slide on each other transverse to the line of motion of the chain. As the link enters the "V" between the pulleys, the ribs on one side push these plates into the channels on the opposing face, and thus the drive is truly positive without possibility of a slip, no matter what the gear ratio or the width of the channels and ribs.

The applications of the drive are many. Its use makes an alternating current motor available for direct variable speed driving, something never practicable before. It can be used as a gear box on all types of machinery that require changes in the speed of operation with a constant source of power. The 5 H. P. unit has a range of from 300 to 1800 R.P.M. with the driving shaft running at 750 R.P.M., and has a transmission efficiency of from 87 to 95%. The gears can also be made so that the speed of the driven shaft is constant, or constantly varied between set limits.



(Copyright) Marine Engineering and Shipping Age

GEARLESS TRANSMISSION SIMPLIFIED

Power Lines have to be built to stand very heavy wind loads. Where a new high-tension line crosses the Sacramento River with a span four-fifths of a mile long, the tallest power line tower in the world rears its top 459 feet into the air. It stands on a foundation of piles driven 80 ft. into the ground under a concrete base weighing a million pounds. The most curious fact is that sixty-six per cent of all this piling and concrete is required for wind load only.

The Huff-Daland "Cyclops," the world's largest single-engined plane, has been recently completed. Up to the present time, it has been known as the "mystery plane" of the army, since it is expected to be the first of our new fleet of bombers.

It has been designed for the new twenty-four cylinder, air-cooled, 1200 H.P. engine now being constructed at McCook Field, Chicago. When loaded, the plane will weigh 17,000 pounds and will have a capacity of 9,000 pounds useful load. A crew of six is required to completely man the ship, whose armament includes ten machine gun mountings and racks for a total capacity of 4,000 pounds in bombs.

The wing span is 85 feet, while the overall length is 65 feet. A high speed of 135 miles per hour can be maintained, and the fuel tanks have a sufficient capacity for a twenty-four hour flight. It can readily be seen that if the space for bombs should be filled with extra gasoline tanks, a trans-Atlantic flight should not present any serious difficulties. The large carrying capacity of the plane, combined with its ability to remain aloft for an exceedingly long period of time, make it of the utmost importance as a part of our national defense.

An all-metal framework has been used throughout, both for the fuselage and the wings. The material employed is welded, seamless, chrome molybdenum steel tubing, which, when properly heat treated, has a tensile strength of 200,000 pounds per square inch.

A Compressed-Air Rifle has been invented in Germany on entirely new principles which may prove to be of revolutionizing importance. Twenty-five rounds of ammunition can be fired in rapid succession, each with a range of over three miles. The bullets, which are very long nosed and sharply pointed have a muzzle velocity surpassing by one fifth the velocity of the modern army rifle bullets, and are loaded into a long device located underneath the barrel and giving the rifle the appearance of the old pump gun. The compressed air is supplied by steel cartridges, one cartridge being sufficient for the discharge of twenty-five bullets.

The Pictorial Section

An illustrated sketch of the paper making process

THE manufacture of paper is one of the most interesting and important of our industries. We are all dependent on paper and the problems involved in its manufacture should be of interest to all engineers.

Paper is made of two classes of material, namely, rags and wood pulp. The better grades of paper are usually made of rags. Linen rags are used for the finest grades of paper such as United States Currency. The rags are shipped to the factory in large bales which are opened and carefully assorted by women who remove any foreign material such as buttons, pieces of metal, sticks, etc. The rags are also assorted as to color in order to get a paper of uniform color. After sorting they are chopped up into small pieces and placed in the digester or rotaries. These are large vessels in which the rags or wood pulp are boiled in a chemical solution for a number of hours. (See Fig. 6) Caustic soda is used in the soda process, acid sulphite of calcium or magnesium in the sulphite process and sodium sulphate (which becomes sulphide) in the sulphate process.

When wood is used the logs are usually taken from trees 10 to 12 inches in diameter and are cut into two foot lengths. The logs are then barked and trimmed to remove knots, seams and decay.

To make ground pulp, the blocks are placed in steel pockets and held against a revolving grind-stone by hydraulic pressure. Chemical pulp is made by chipping the wood into small pieces and cooking them in the digesters already described. After boiling, the material goes to the heater which consists of a large oval tub furnished with a vertical wall parallel to the major axis of the tub, called the midfeather. A revolving horizontal roller equipped with knives is placed between the midfeather and the wall of the tub (See Fig. 11). The pulp or rags circulate through the beater for 10 or 12 hours in which time it is cut up into very small pieces. While in the beater a mineral "filler," usually china clay, sulphate of lime or starch, is added to fill the pores and give weight to the paper. Dyes and rosin sizing are added in many cases. The sizing is added to give the paper a glossy finish and to make it less absorbent.

From the beater the pulp passes through a machine called a Jordan (Fig. 10) in which it is still further mixed and beaten. The Jordan consists of a cone equipped with knives which revolves at a very high speed within a conical case similarly equipped. The stock is made to flow between the case and the rotor knives, the fibers thus being thoroughly separated from each other. The rotor can be moved endwise to change the clearance between the two sets of knives, a closer adjustment producing a finer pulp.

After leaving the Jordan the stock is carefully screened, thinned, and pumped to the paper making machine called the Fourdrinier. A view of a complete machine is given in Fig. 4.

In the Fourdrinier the liquid stock flows out on an "apron" of waterproof cloth by means of which it is spread over the width of an endless belt of fine wire screen woven with sixty to ninety meshes to the inch. (Fig. 8) This belt travels horizontally, over many small rollers, through which the water immediately begins to drain away. The belt is given a sidewise shake as it progresses so as to felt the fibers crosswise as well as lengthwise. For newspaper work belts 200 inches wide are used and they travel 500 feet or more per minute. For books and writing paper the width is from 60 to 70 inches and the speed 60 to 400 feet per minute. "Wove," "laid," and "watermarked" papers before leaving the wire belt pass under a light wire roll called the "dandy" which impresses the proper design on the paper. For wove paper the dandy has the same number of wires as the belt below. Laid paper has parallel lines about an inch apart crossed at right angles by lines quite close together. From the wire belt the still moist tender web of paper passes, supported on a belt of felt or canvas, through two or three pairs of massive press rolls which are sometimes made of granite (Fig. 1 and Fig. 9).

From there it runs alternately under and over a number of steam heated metal cylinders called the driers. Fine papers may receive at this point a "tub" sizing in a vat of gelatin solution and be dried on moving racks (Fig. 2) in a room having a temperature of 80 to 90 degrees Fahrenheit. Next the paper passes through the "calenders" (Fig. 7 and Fig. 12), stacks of chilled iron rolls which smooth it, producing a "machine finish." It is then wound on a reel and passes to the "slitter" which trims the rough edges and, if necessary, cuts the roll into two or more narrower ones. News print paper is ready for the printing press at this stage. Fine papers for some kinds of book and magazine work may be supercalendered or given a hard smooth finish in a supplemental calendering through alternate chilled iron and paper rolls under great pressure, or they may be "coated" with glue or casein and china clay or some other mineral which gives a finish which is smooth, but softer than that of super-calendered papers. Glazed papers of the type used for covering paper boxes are given a very glossy finish by calendering in a machine where a top roll of hot iron revolves much faster than the roll below.

The calendering rolls shown in Fig. 7 are driven by the motors shown in Fig. 5. The Fourdrinier illustrated in Figures 8, 9 and 4 has a sectionalized power drive. There are nine sections, each driven by its own motor, all of which are carefully synchronized with each other.

Paper mills discharge large quantities of waste into the rivers and legislation is being enacted compelling paper manufacturers to provide filters and settling chambers for their waste. Fig. 3 is a view of a very interesting device called a "Save-All" designed to recover the pulp fibers from waste water. A large cylinder revolves partly submerged in the water. Its surface is made of a very fine wire mesh screen and partitions inside divide it radially into separate compartments. Suction is applied to the submerged compartments and the water flowing in deposits the fibers on the screen. When a section has reached a point past top center, air pressure is applied to blow the matting of recovered fibers off the mesh into a receptacle. Material so recovered can be mixed with fresh pulp.

In connection with the composition of this pictorial section we are very much indebted to the P. H. Glatfelter Co., the Champion Coated Paper Co. and the West Virginia Pulp and Paper Co. for their cooperation in furnishing us with photographs and information.

ADAM K. STRICKER, JR.

© Champion Coated Paper Co.

FIG.1 PRESS AND ROLLS

© Champion Coated Paper Co.

FIG.2 DRYING RACKS

© R.H. Glatfelter Co.

FIG.3 SAVE-ALL

FIG.4 FOURDRINIER

FIG.5 DRIVING MOTORS

© Champion Coated Paper Co.

FIG.6 BLEACHERS & DIGESTERS

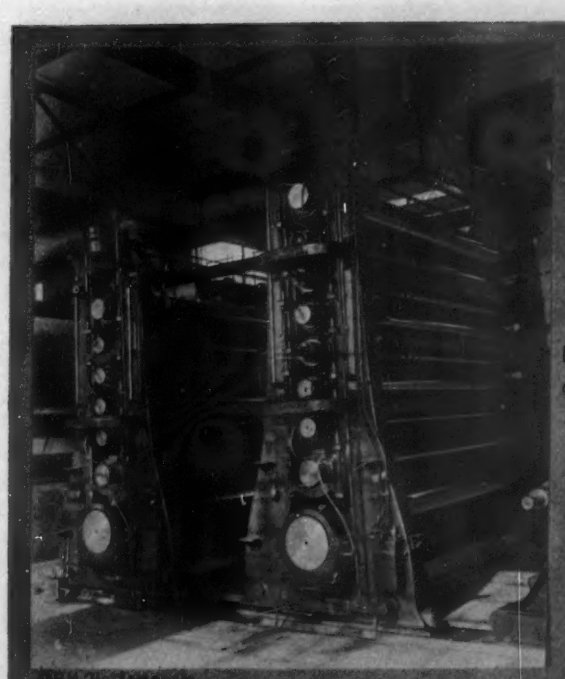
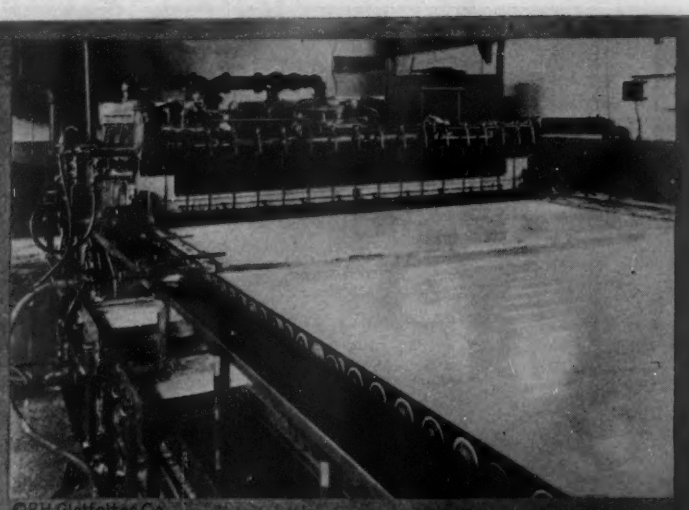


FIG. 7
CALENDER
ROLLS



©P.H. Glatfelter Co.

FIG.8 FOURDRINIER - WET END

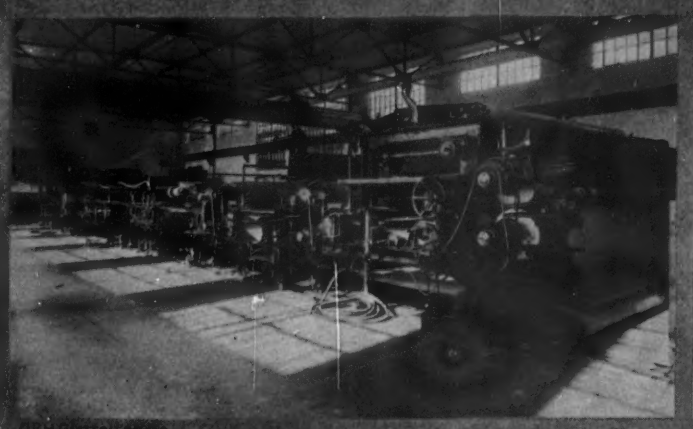


FIG.9 PART OF FOURDRINIER

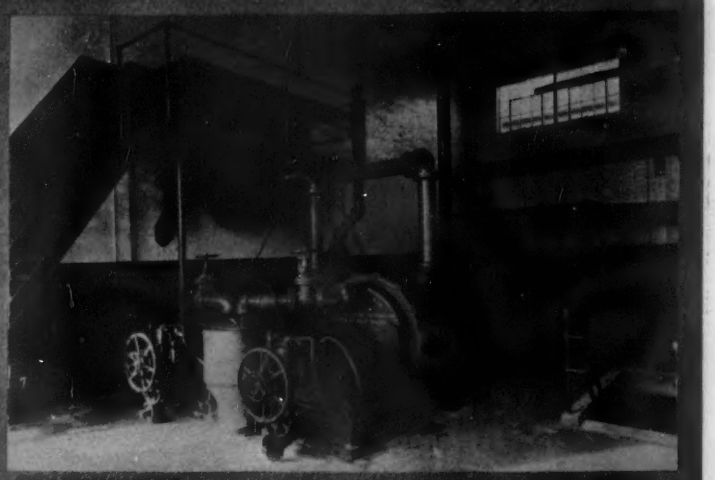


FIG.10 JORDAN

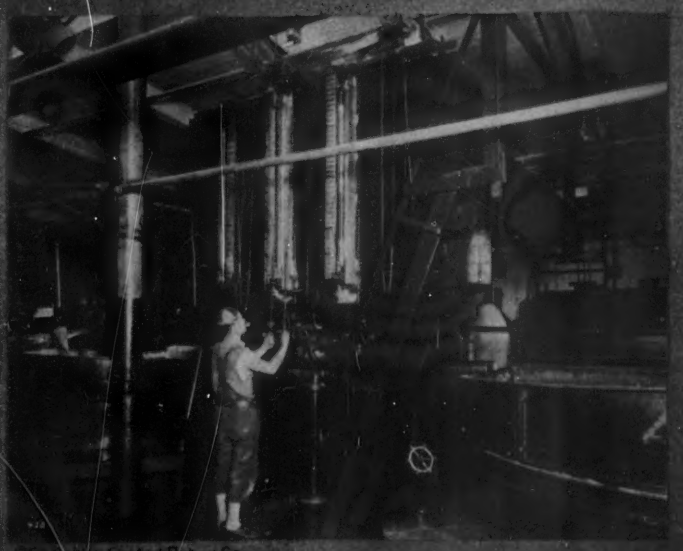


FIG.11 BEATERS

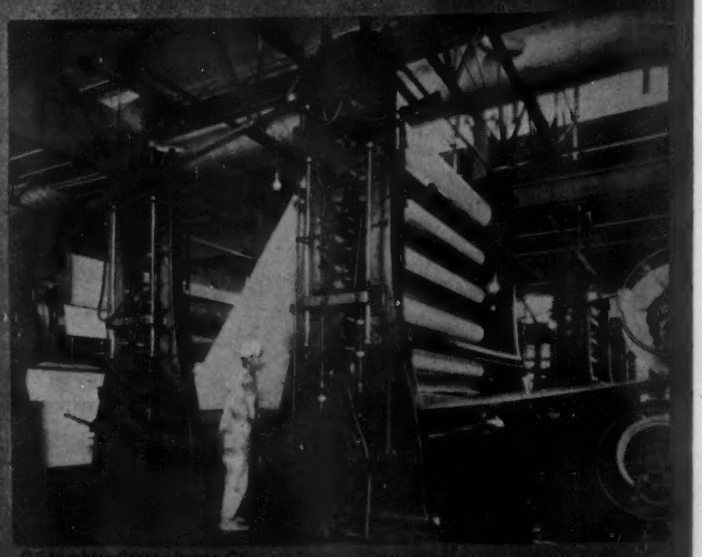


FIG.12 CALENDER ROLLS OPERATING

Editorials

INTERNATIONAL SCHOLARSHIPS

Mme. Curie may well succeed in easily accomplishing a step toward world peace that others have been struggling over for years. The international character of science and scientific research is the foundation for her undertaking which is now before the League of Nations. The project will be the means of binding together the foremost scientists and thinkers of the day and will make possible a broad, international outlook for the younger generation of scientists and scientific students.

Mme. Curie clearly discerned that although the world has always been quick to recognize the attainment of success, it has done too little to help those of unknown talents. Men who have made a name for themselves by reason of their ability are soon provided with laboratories and leisure to continue their researches. But until recognition is attained, important work is too often hampered by lack of facility and finances. Mme. Curie's proposal is to establish an international scholarship organization which will particularly serve as a means of fostering students who show promise, although they may not yet have had time or training to establish reputations for themselves.

"A complete foundation would control scholarships of two grades—minor scholarships for beginners in scientific research or post-graduates work, known as probationary scholars; and major scholarships for workers who had given proof of their capabilities, and who might be called research fellows. Between these two categories there should be a regular proportion—for example, one research fellowship to two or three probationary scholarships. It would be preferable for a foundation to include both categories, for then it might follow up its probationary scholars, acquire a just estimate of the choice of vocations, and establish a fair proportion between the two grades of scholarships.

"The international character of the scheme would be ensured by the deletion of all clauses relating to the nationality of the scholar. On the other hand, I do not think there is any need to object at present to the desire of certain donors to bestow their endowments on a specified university or laboratory, as laboratories form the centers round which scientific work naturally groups itself. However, the scholarship endowments known as traveling scholarships, which may be held at a research center chosen by the candidate, should be encouraged."

Further details of the plan are not necessary to the formation of an opinion as to its value. We certainly wish it the success in the hands of the League of Nations which it deserves.

Our respects to Mme. Curie.

THE COVER

The etching reproduced on the cover of this month's TECH ENGINEERING NEWS is by Joseph Pennell. "The Nation's Business" speaks of the subject as follows: "Mightiest of the steel-arch bridges, it now spans the East River at New York in a single thousand-foot leap. Few of those who cross it today think of the imagination and skill that threw the five-hundred foot halves of the steel arcs together in the air without the aid of any supporting structure." Hell Gate Bridge is one of the most pictured and well known engineering structures in the United States and needs no caption to identify it.

PUBLIC SERVICE INSTITUTE

Under the auspices of M. I. T. and the Massachusetts Civic League there will be held a Public Service Institute from March 16-18 at Tech.

The purpose of this Institute is to discuss the significance to the community of the various governmental functions and the necessity of trained personnel for their effective administration.

Mr. James P. Munroe, secretary of the Corporation, is chairman of the committee in charge of the meeting. Addresses will be made and conferences conducted by speakers of national importance, members of the faculties of the various colleges in Massachusetts, public officials and others in the public service.

About fifty papers will be presented during the Institute. They will include public works problems, public health, community planning and traffic regulation, promotions and removals in public service and the work of investigating experts in the administration of government.

These problems affect every engineer, either in his professional work or in his social life. The list of Technology alumni who have made notable contributions to society through work in this field is very long, and the accompanying review of their works is impressive. For these reasons, if for no other, it is fitting that Technology should play the leading part in bringing the engineers engaged in this sort of work together, to help create in them a group consciousness and a concentration of effort directed toward gaining due recognition for the service rendered by that group.

ENCOURAGING SIGNS

Students of Course XVI who recently made a trip through the aircraft establishments near New York have brought back some very interesting comments on a phase of the aircraft industry which is vitally interesting to the embryo aeronautical engineer at Technology—namely, the wages paid to graduate engineers.

The commentors were all delighted and very much impressed by the fact that everywhere they went were Technology men in the organization. The list contains many with titles such as president or chief engineer, which is still more encouraging. Even the chief engineer of Sikorski's all-Russian organization studied at Technology before he attained his present position. But about this matter of wages: One company offered seventeen dollars a week to graduates. Another thought it was doing pretty well to offer twenty-two dollars. The highest offer was twenty-seven dollars a week.

These figures seemed to be pretty low to many of the students, who all seemed to know of plenty of cases of Technology graduates starting out at thirty-five dollars a week or more in other fields. The important fact to be considered on second thought is that, in spite of the status of science in general and the complicity of the science relating to flight in particular, the industry is still in its infancy. Think of what you know concerning wages in the electrical industry when it was getting started. Yet that is now a profitable field of endeavor for engineers—especially for those engineers who started out with it in its early days. And no one will deny that the automotive field is interesting or lucrative. But in the infant days of every industry, when capital was first being attracted to the field because of prospective future profits, rather than sure present profits, capital cut all the corners it could at the time in order to hold down immediate losses.

The present low wage offered is a sign of encouragement. The industry is still young and holds promise to the engineer who enters it now and grows with it.

Departmental Notes

PROFESSOR D. C. JACKSON

ELECTRICAL ENGINEERING DEPARTMENT

The Dynamo Electric Machinery Division, perhaps more familiarly known to the student body as D.E.M. or E.E. Lab., is under the direction of Professor C. E. Tucker who is aided by some fourteen Instructors and Assistants. This Laboratory gives experimental courses relating to stationary and rotating electrical power equipment.

The first term of the present scholastic year saw registered 372 students taking courses in the laboratory. Broadly, the subjects can be divided into three groups as follows: Group 1 which is designed to meet the requirements of non-electrical students such as those in Courses I, II, III, IX, X, XI, XV-2, and XVI. The subjects in this group cover only the more common and fundamental electrical measuring and power devices. Group 2 consists of subjects designed to suit the needs of the Electro-Chemists, Course XIV. The experiments in this group are more numerous and cover more types of equipment than those of Group 1. This arrangement is in recognition of the expectancy that the Electro-Chemist will be required in his work to handle much more electrical machinery than the student of Civil Engineering or Business Administration. Subjects in Group 3, arranged for students in the Electrical Engineering Department, contain the most complete experiments which are designed to give a thorough theoretical and operating knowledge relating to present day electric generating and motive devices. As a part of all courses an excellent understanding of the necessary protective, switching, and measuring accessories is attained. Two special subjects are regularly given for the Army and Navy Officers whom the Government send yearly to Technology for special technical training.

Of the 372 students registered for work in the laboratory this term, non-electrical students number 140, the Electro-Chemists 22, and the Electrical 202. Besides these there is a small group of students taking up miscellaneous work in the laboratory. Also the laboratory provides space, equipment, and supervision to those students who carry on experimental theses relative to electrical machinery. The latter fluctuates seasonally but averages a good 2000 laboratory hours per term.

The general layout of the laboratory, types and sources of power available, equipment, and the conduct of student work is well worth consideration.

The laboratory, located in building 10, is two stories high with a balcony on all four sides. On this balcony is located small apparatus such as motors from one to five horsepower, transformers, and mercury arc rectifiers. This equipment is fixed in place and except for measuring instruments and connecting leads, is provided with the necessary accessories for testing purposes. The balcony, besides housing several staff offices, has set aside for student use a large, light space furnished with chairs and tables. This gives to the students a convenient meeting and working place where association with each other allows group discussion and the profitable interchange of ideas.

The main floor of the laboratory is used for the larger and heavier machines. These machines can be easily moved about by the ten-ton traveling crane which serves parts of the main floor and the balcony. Thus several machines can quickly be grouped together for some of the more complicated tests.

The capacity of the individual pieces of apparatus on the main floor varies from 5 to 30 horse-power for motors and from 5 to 25 kilo-watts for the generators. Larger units, however, are available for special tests. Altogether, there are over 150 important generators, motors and transformers in the experimental equipment. By using units of medium capacity it is possible to have sufficient duplication of apparatus without unlimited space and finances. Small units have the distinct advantage that students can be left more on their own responsibility without undue danger either to themselves or to the apparatus. Further, large sized units are not necessary for educational purposes, as the principles of operation are sufficiently illustrated by the smaller units provided proper types of machines are chosen. This latter requirement accounts for many old type but suitably operating machines that may be seen in this laboratory. The duplication of apparatus is essential in order to handle sections of a reasonably large number of pairs of students. The laboratory can handle about 30 groups of students at a time. It has been found from experience that five or six student groups require the attention of one Instructor while in the laboratory, and the laboratory has Instructors on floor duty in this ratio so that students can quickly secure advice in times of difficulty.

The Institute power house is the primary source of power for the laboratory. It can directly supply three-wire 115-230 volt direct current and three phase, four wire, 133-230 volt, 60 cycle power. By use of Scott connected transformers in the substation, located in the laboratory, the three-phase system of the power house can be transformed into a four-phase, five wire system, thus making also available sixty cycle power at 115, 163, and 230 volts. When the laboratory is carrying a light load the direct service from the power house is suitable for experimental purposes but heavy loads characterized by much starting of machinery causes the voltage to drop and be rather erratic. This annoyance is overcome by running our own substation. This substation besides being able to generate the same types of power as the power house can also supply three phase 24 cycle power at 230 volts.

Each of the generating machines in the substation is equipped with its own voltage regulator, by which constancy of voltage may be maintained regardless of the fluctuations in load. The substation also contains a special three-phase generator designed to give a very close sine-wave of voltage. The output of this sine-wave alternator, by a system of transfer leads, may be quickly trunked to any of the laboratory power distribution panels. The sine-wave alternator is used generally for special tests and investigations. Its prime mover is a direct-current shunt motor whose speed may be controlled at the place of experimentation by use of transfer feeders.

(Continued on page 30)

The apple that rocked the earth

"I wonder why?"

In Isaac Newton's mind that question clamored for an answer. Many men had seen apples fall, but this man with the question mark mind found out why they fall—and his answer has helped us to understand the workings of a universe.

Would that we all could get a bite of that apple if it would inspire us too with the "I wonder why" attitude!

Intellectual curiosity is a great and moving force. It mobilizes reluctant facts. It is the stern drill-master which whips into shape that most invincible of armies—sure knowledge.

Curiosity, with the will to sweat out the answer, is the greatest asset you can acquire in your college course. This attribute is needed by industry today more than ever before.

Published for the Communication Industry by

Western Electric Company

Makers of the Nation's Telephones

Number 65 of a Series

Reprinted by request

Here and There

Humorous notes from the Editor's desk

WRONG NUMBER

Hello! This is Prof. Prescott speaking. Please send up two quar... No you have the name wrong. This is Prof. Prescott, Nobody's "Mascot"! PROF. PRESCOTT. *P* as in Peritonaeum, *R* as in Regurgitation, *E* as in Endocardiac, *S* as in Syzygetic, *C* as in Cephallic, *O* as in Opthalmascope, and two *Ts* as in Ptomaine.

SHORT SKIRTS

We marvel at the great accomplishments of the research engineer in late years. For example, it has been the research engineer who has developed rayon to the point where it is two hundred times stronger than the rayon of three years ago. As a result attractive stockings have been placed within the reach of millions more attractive young women and has thus helped to shorten skirts. This is the way our civilization advances. Probably in the near future the research engineer will develop a new pair of glasses with the lower part darkened.

"SCIENCE"

Excerpt from a well known magazine's "Scientific Page"—"A new non-inflammable gasoline that will not take fire or explode will doubtless save the lives of many aviators."

We wonder why the "science editor" of that magazine does not suggest using carbon tetrachloride.

CABBAGES AND KINGS

Special Dispatch to the A. P.—London, February 30, 1927. "It is rumored on good authority that the firm of Jones, Smith and Co. will soon run tests upon a new speed boat of their own design which is expected to revolutionize boat-building practise. The craft is reported to be expected to develop a speed of 75 square feet at an estimated fuel consumption of a little over an hour a day. The design of the hull differs radically from that of existing models, the ratio of length to beam being several gallons, while its draft is only a few ounces."

If such a news item were actually to appear in the daily press, few persons reading the nonsense would fail to appreciate the utter confusion of terms having to do with measured quantities; and having read the item with feelings of amusement or of disgust (perhaps both) might be mildly interested to know what really was intended. The fact of the matter is that with the present acquaintance on the part of everyone with accepted units of length, speed, and so on, it is very unlikely that any such "news" dispatch would ever reach the composing room in the form quoted. It often happens however that less well understood units, such, for instance, as the units of mechanical power and of work are freely misused. This is because the significance of these units is not so thoroughly appreciated by the general public. Particularly is this noticed in the case of those short items or paragraphs whose sources are obscure and which are used as "fillers" by many newspapers without any attempt at editing. Not long ago a Boston daily paper carried this bit of information: —"MUCH WIND POWER." "The enormous energy stored in the winds of the world could run all the factories in the United States for more than 400 years."

Another reads, "STOPS COST MONEY"—"Twice as much power is required to stop an express train as to start it."

Let a bit of news or near-news involving electrical apparatus or terms originate anywhere and it is at once rushed into print, possibly with reportorial embellishments but probably without editorial correction. The result is that it is unusual to find in the daily press any reference to things electrical that is not accompanied by gross misuse of electrical terms. Not many years ago, if people observed or heard about any mysterious phenomenon, they looked at one another, wagged their heads, said "Electricity does that," and were quite satisfied to let it go at that. Nowadays with electrical circuits all about them, with electric lights, telephones and radios in their homes, they feel much better acquainted with electricity the agent, although still very hazy about measurements and units in the electrical system. Most newspaper men have just as hazy notions about these things as have the general public, so that it is not difficult to understand how carefully edited papers may fail to use electrical units in their proper significance. Read these few press notices taken at random, and see whether or not you would suggest any revisions.

"The actual amount of electricity in a lightning stroke is relatively small, having been estimated at a commercial value of 30 cents." "The maximum resistance of rubber insulators is about 1000 volts." "One town buys current from a private concern and then retails it to users at 10 cents an hour."

"During the five-year period 1920-25 there was a 51 per cent increased consumption of electricity in the United States."

"ARE YOU MAGNETIC? Watches are sometimes seriously affected by the magnetism of their wearers. In most cases those who have this effect are dark complexioned."

"SHOCK TOO GREAT TO CAUSE DEATH. Man will live after 13,800 volts hit him."

"22,000 VOLT CURRENT LEAPS FROM WIRES."

Notice how many of these queer statements you can find, and always remember that Technology men can do useful missionary work in carrying with them to the four corners of the earth the true significance of the more commonly needed electrical terms. and in aiding the various news bureaus to use these terms with a high degree of precision.

"FROM LITTLE ACORNS"

"Little things sure can mount up," said the flea. "Take for instance, the H. J. Heinz Company. Last year they saved $40,000 by an efficiency engineer's discovery that it took seventeen instead of eighteen drops of solder to close a certain kind of can."

WHAT'S THE MORAL?

When Permalloy, the highly magnetizable alloy of nickel and iron was first discovered, it had but one, and apparently insurmountable, defect. No flux could be found with which to weld it. There was one engineer in particular who was determined to weld permalloy. He had been working hard one hot summer's day, and naturally perspired quite freely when he would bend over the hot metal. Feeling rather discouraged, he forced the ends of the metal together with all his strength. A great drop of perspiration rolled from his forehead, and sizzled on the hot metal. To his great satisfaction and perpetuation of his name, etc., the pieces united. One of the salts in the secretion had done the trick.

Koehring Re-mixed Concrete

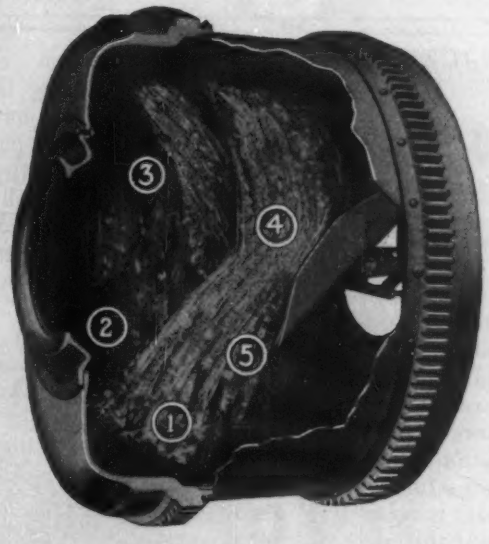
is Dominant Strength concrete

IN addition to the use of proper aggregates, positive control of the thoroughness of mix and the correct amount of water accurately timed, there is finally, an essentially important factor in the production of standardized concrete of Dominant Strength. It is the proper mixing action.

The raw materials—cement, sand, stone and water—must be so combined and mixed that the resultant concrete will be of maximum strength and quality. The drum of the Koehring concrete mixer has been designed to produce a re-mixing action which coats every particle of aggregate thoroughly with cement. Tests have proved that the Koehring five action re-mixing principle accomplishes this most completely.

Koehring supremacy inside the drum goes even further. With the Koehring re-mixing action there is no separation of aggregate according to size—it is uniform to the last shovelful of every batch.

"Concrete—Its Manufacture and Use" is a 210 page treatise on the uses of concrete, including 26 pages of tables of quantities of materials required in concrete paving work. To engineering students, faculty members and others interested we shall gladly send a copy on request.



(1) Blade cuts through materials with churning action. (2) Blade carries materials up, spilling down again against motion of drum. (3) Materials hurled across diameter of drum. (4) Materials elevated to drum top and cascaded down to reversed discharge chute which (5) with scattering, spraying action, showers materials back to charging side for repeated trips through mixing process.

KOEHRING COMPANY
MILWAUKEE WISCONSIN

Manufacturers of Pavers, Mixers—Gasoline Shovels, Cranes and Draglines

Professional Notes

A brief but interesting article dealing in a straightforward manner with this unusual subject

AERONAUTICAL ENGINEERING SOCIETY

During the Christmas vacation, the Aero Society ran a trip for its members under the guidance of J. C. Reddig, '29, to two of the large aeronautical plants in the vicinity of New York. On the morning of December 30th, ten members assembled and visited the Wright Aeronautical Company, builders of fine aircraft motors.

The plant was occupied at the time with a contract for their new J-5 200 horse-power aircraft engine, a further continuation of the very well known and successful J-4 "Whirlwind" engine, that is powering most of the planes on the new Commercial Air Mail routes, and which was used by Commander Richard Byrd so successfully on his North Pole flight last year. The new series of engines are of the same power, but have refinements that will promote their economy, ease of maintenance, and notably their period of life, which is already longer in actual service than any other aircraft engine. During the past year, the U. S. Naval Air Station at Squantum, Mass., flew one of these motors over 400 hours, without overhaul or repairs of any kind, except the replacement of valve springs which were frequently drenched with spray.

The inspection party went completely down the manufacturing line from the foundry to the assembly room, and then to the testing room, where all the motors are run in under their own power for at least twenty hours. The group also saw the new "Cyclone" 525 HP. engine which was recently announced publicly. The engine was being prepared for its 50 hour test which it passed with flying colors. It is the largest of the American Radial air-cooled motors.

The party was entertained at lunch by the Wright Company, and then proceeded from Paterson to Hasbrouck Heights to visit the Fokker Aircraft Company's plant there. In this factory they saw work on several of the large tri-motor Fokker Transport plane under construction for the Colonial Airlines, who are now flying the mail between Boston and New York. These planes are identical except for cabin arrangement with the Plane that Commander Byrd used on the North Pole Flight, and are the same as the Philadelphia Rapid Transit Company was operating between that city and Washington during the past summer, except that they have accommodation for two more passengers. A large twin-engine ship for the U. S. Air Corps was also well along on the assembly line. A splendid opportunity was afforded to inspect the detailed construction and the construction methods employed.

Upon leaving the plant the group was attracted by activity on the Teterboro Airport nearby. The Wright Bellanca Cabin plane was preparing for a flight test with a newly installed J-5 motor. Although eight were already in the cabin, two members of the party were invited for the flight, and the little plane with only 200 HP took off and flew well with ten people in her cabin.

F. T. KURT, '27

CORPORATION XV

A combined dinner meeting with the Boston Chapter of The Society of Industrial Engineers was held in North Hall, Walker Memorial on December 15, 1926.

Mr. Albion N. Doe, who is a graduate of M. I. T. Course XV, was the guest speaker. His talk entitled, "What I Know About Industrial Engineers" was most instructive, and clearly defined the term "Industrial Engineers," which has been subject to much abuse in the past, and which has only been vaguely understood by many. The gathering was privileged to hear from several members of the Boston Chapter of S. I. E. in the discussion which followed, as well as a few remarks from one of Corporation XV's honorary members, Dr. Davis R. Dewey. Mr. Doe was afforded unlimited opportunities to display his ability at answering questions.

The activity of Corporation XV, which at the present writing is commanding the most interest among the stockholders, is the New York Trip. This trip, which is an annual affair, was made on January 31st to February 2nd, for the purpose of visiting several modern manufacturing plants and engineering projects. The itinerary included The Eighth Ave. Subway Construction project, The New York Stock Exchange, The New York Edison Electric Plant, Loose Wiles Biscuit Co. of Long Island, N. Y., Bush Terminal Warehouses, Brooklyn, N. Y., and the Western Electric Company, Kearny, N. J.

Through the courtesy of Mr. Doe, president of the New York chapter of The Society of Industrial Engineers, students who made this trip as well as the alumni of Corporation XV were invited to attend a special meeting of the society on February 1st which was held at Keen's English Chop House in New York City. At this time the members had the privilege of hearing Miss Lies, personnel director for Macy's department store, Mr. L. P. Alford, editor of the Management Handbook who discussed the subject of management, and Miss Witte, who was visiting America, and who spoke on "Management in Germany."

This year the trip appears like one of the most successful which the organization has conducted in recent years, and with the cooperation of the students it is expected that the trip will aid in gaining a better conception of modern industrial problems.

ALDEN G. REED, '27

ELECTRICAL ENGINEERING SOCIETY

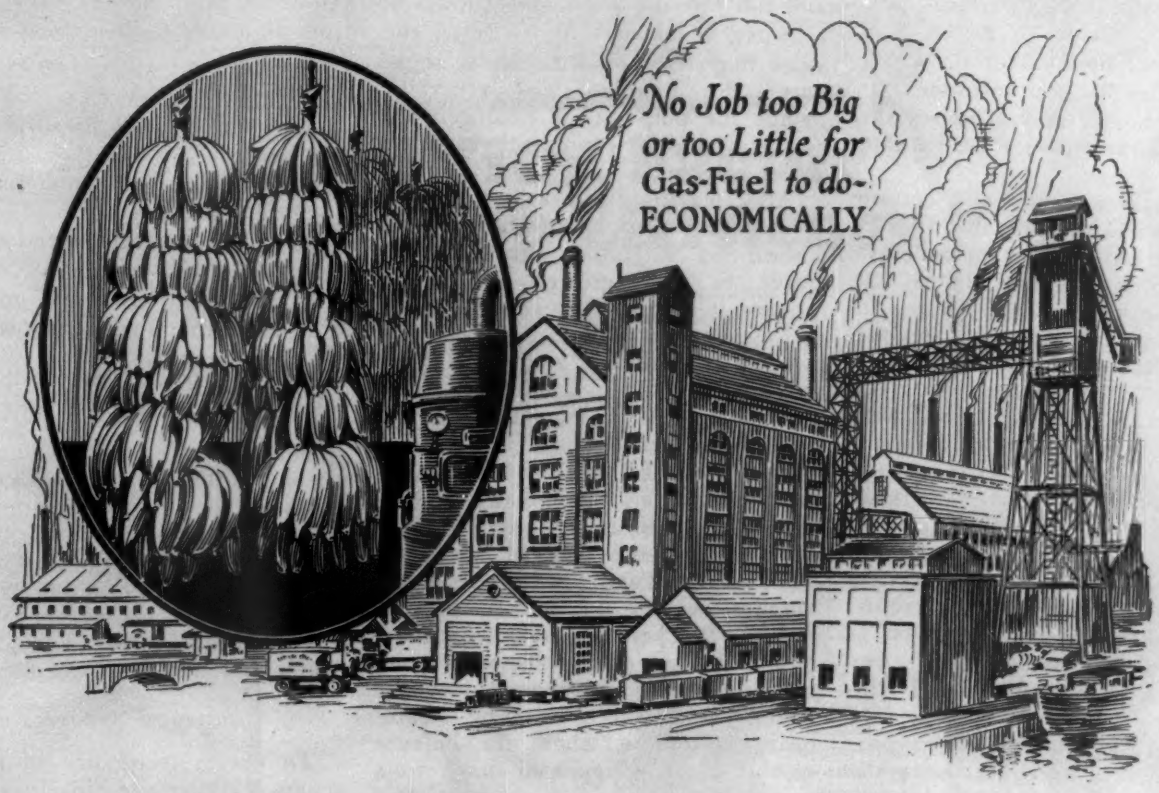
A decided innovation in final examination procedure is to be inaugurated by the Electrical Engineering Department this May to increase attendance of M.I.T. students at the Student Convention of the American Institute of Electrical Engineers which will be held on May 26 and 27 at Pittsfield, Massachusetts. Those fourth-year students with good term records will be excused from the final examination in Principles of Electrical Engineering, if they attend the convention.

At the Technical Sessions seven student papers will be presented. Electrical Engineering theses may be submitted for presentation. The papers will be eligible for the National and Regional Student Paper Prizes. The competition of student papers for this convention closes on April 15.

On January 12, 1927, Mr. R. H. Rogers of the Industrial Engineering Department of the General Electric Company, addressed the members of the M. I. T. Branch of the A.I.E.E., speaking on "Four Practical Problems Confronting the Engineer." The problems were based on the Ward Leonard method of motor regulation and brought forth spirited discussion.

EDWARD A. MICHELMAN, '29

There's Romance *in the* Story of Gas as a Practical Fuel



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Paper Mill Engineering

(Continued from page 5)

News-print is a low-grade paper in which short life is no detriment, and no attempt is made to get a pure white. The elimination of the intercellular matter is not desirable. It serves as a binder and increases the percentage of raw material turned into paper.

For mechanical pulp only certain woods are satisfactory, notably spruce. The logs as received at the mill are cut into two or four foot lengths, put in a machine known as a grinder, in which large grindstones work against the side of the log, paring off the fibres together with their binding material, the whole mass being kept well wet. When so ground, excepting for some screening to take out bits of bark or foreign material, it may be said that the manufacture of ground wood pulp is complete. Before being sent to market, if not to be used at the mill where made, it is necessary to get rid of the excess water, which is done by pressing and running over hot cylinders, thus driving off the water as steam.

Outlining the chemical pulp process as applied to wood, this being the chief raw material used, the logs as received at the mill are cut into chips about $\frac{5}{8}''$ square and $\frac{1}{8}''$ thick. These chips are then carried to digesters, large tanks capable of withstanding steam pressures up to 130 lbs. In these tanks the chips are cooked by various processes, such as soda, (NaOH), sulphate, (Na_2SO_4), sulphite, [$Ca(HSO_3)_2$] (approximate) and various other less known processes. The object of each of these is to dissolve out as much of the binder and as little as possible of the fibre. The care exercised in carrying these out varies with the quality of paper desired.

Following the cooking process is the washing of the cooking liquor from the pulp, with attendant recovery of chemicals used, the screening of the pulp manufactured, and excepting for Kraft papers, the bleaching, removing the last traces of the lignin into cellular matter.

Pulp from rag stock is prepared by cooking with weak caustic lime, washing and beating, the process in general being much simpler than the two previously mentioned but requiring much more labor due to a large amount of hand cutting and sorting.

From the pulp mill several grades of pulp are brought to the paper mill; these are blended to bring out the proper qualities in the required paper and run through a machine known as a beater, which not only hydrates the stock but straightens the fibres, separates the bundles, and generally brings the pulp into a homogeneous mass suitable for running through the paper machine.

After leaving the beater the stock is generally run through what is known as a Jordan, bringing the fibres to still greater uniformity. Thence it goes to the paper machine.

Paper machines are in general of two styles—cylinder and fourdrinier. In each case there is a fine wire mesh, for the "cylinder" machine wrapped around the cylinders, in the case of the "fourdrinier" in the form of a belt, both so arranged that receiving the pulp thinned out to the consistency of thin milk, the bulk of the water will run away and the fibres remaining mat together to form a sheet.

From this point the sheet as formed passes through press rolls, assisted by woolen felts to aid in removing the water, thence on to rotating steam-heated cylinders, where the balance of the water is removed down to a point of perhaps 5% of the solid matter weight. From the paper machine paper is prepared for shipping by re-rolling, or making up into packages, or is sent to a coating mill for application of coating to one or both sides to give it different qualities.

The above is a brief outline of the main systems of manufacturing paper in this country, and as such appears comparatively simple. However, to carry these processes through requires auxiliary machinery, which cannot be well touched on here. It requires from the paper maker and engineer a knowledge of chemistry (organic and inorganic), physics, heat, and electrical phenomena, all for a successful mill of the highest order.

The engineer is called in on the job usually very early in the proceedings, to get his ideas on power, the possibility of hydraulic development, available mill sites, railroad connections, transportation, water supply and waste disposal, before or perhaps after rights to timber lands and other sources of raw material have been acquired. In the case of additions to existing plants probably he is not called in until it has been decided to increase the capacity, the raw material and the paper market being in sight.

Assuming that preliminary studies have evolved suitable mill site, transportation facilities, fuel and labor supplies, the problem must be studied from all angles to insure:

1. Continuity of operation
2. Ample supply of good water
3. Ample facilities for disposal of waste
4. Minimum raw material requirements
5. Minimum transportation, external and internal
6. Minimum labor and upkeep
7. Minimum fuel and power requirements
8. Low first cost
9. Quality product

sometimes more weight being applied to one of the above factors, sometimes to another, depending on the grade of paper and pulp required. However, without the first and last items listed, sales would be few. Without low operating costs and low fixed charges competition cannot be met and a profitable business maintained.

Continuity of Operation

To obtain continuity of operation means high-grade machinery with ample capacity. Digesters, grinders, screens, beaters, fourdrinier or cylinder machines, boilers, turbines, generators, pumps, all placed on solid foundations above flood lines enclosed in substantial buildings, well heated and ventilated with little fire risk involved. It calls for the best grade of shafting, pulleys, belting, motors, pumps, to operate 24 hours per day, six days per week, under load conditions varying greatly from hour to hour, minute to minute. It calls for pipe lines well laid, free from rust and scaling, often installed in duplicate, with power lines — both steam and electric—well worked out, well insulated, on ample supports. It calls for careful study of storage and reserves between processes, whether continuous or batch, with facilities for checking chemical and physical changes in material due to variation in raw material, changes due to heat, interruption of flow, etc.

Waste Disposal

As each ton of pulp made requires from 20,000 to 150,000 gallons of water, depending on grades, qualities, etc., much of which water is at one time or another in close contact with the finished product, it is necessary to have a clean source of supply

(Continued on page 28)

A Vital Factor in Shop Efficiency

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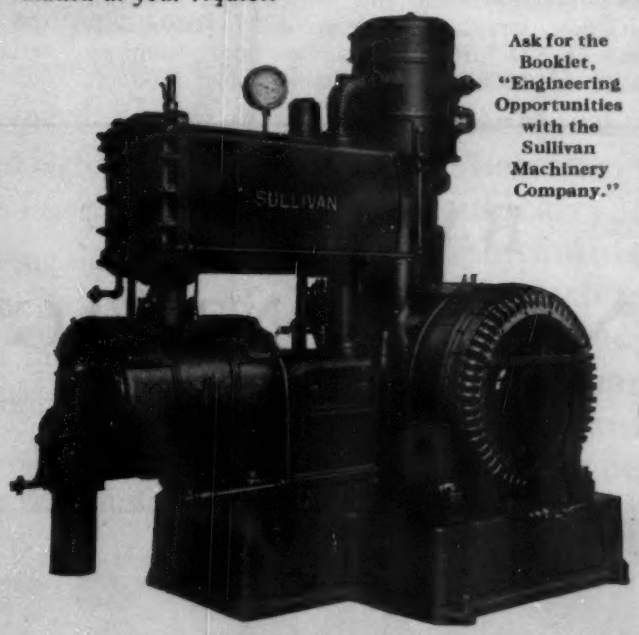

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Paper Mill Engineering

(Continued from page 26)

or provide filters to make it clean. With certain lines of paper softness is also an essential in the supply. Oftentimes setting basins with coagulant facilities are necessary. The quantity of water used is so great, particularly as a conveyor, that a flow requiring a minimum of pumping is desirable.

The finally rejected water, carrying much of the inter-cellular matter of wood or other raw material, as well as other waste products, whitened by lime and clay or blackened by sulphite liquor, must go to a stream of large volume or to settling and evaporating basins. This problem of waste disposal is becoming of increasing importance as stream flow diminishes and as population increases. It is being met by the reuse of much of the water, by reburning lime, concentration of solutions of inter-cellular matter, and burning.

In connection with the water supply, that for the boiler plant must not be overlooked as the water quite suitable for paper-making might miss desirable boiler water by a large amount. The total water requirements of a mill parallel that of a sizable city, for instance, one mill in mind having a product of 400 tons per day pulp and paper would require 20,000,000 to 30,000,000 gallons of water a day, enough to supply a city like Worcester or Providence. Bacteriologically, this supply need not be as pure as required for domestic work.

In handling this water high-efficiency pumping plants are desirable, although under certain circumstances efficiency is commonly sacrificed for continuity of operation and ease of control.

An ample supply of water is necessary for fire protection. The industry though not really hazardous has at times suffered severe losses in wood piles containing thousands of cords. Pumping capacity of 3,000 to 10,000 gallons per minute supplying 1½" monitor nozzles furnish desirable protection.

Raw Material

Whether this will be rags, wood, or straw, would be decided by the manufacturer. For rags we might count on 80% going into the finished product; with ground wood, perhaps 80%; for chemical fibre 25 to 35%.

It is necessary to select the process most carefully to suit the raw material and finished product, having due regard to the technical skill available for operation. A balance sheet is, of course, desirable to account for all materials as a bookkeeper takes care of his money in and out. Unfortunately the incoming materials in the shape of wood or straw are subject to wide variations in moisture loss of bark and rotting in piles, and as at intermediate stages of process the cost of measuring is very high a real balance in and out is not usually possible.

It is desirable to keep large quantities of raw material on hand, as, for instance, wood is difficult to procure in winter time. Seasoning of the wood brings it more nearly to an average grade. A mill carrying 60,000 to 100,000 cords of wood is not uncommon. The cost of handling and rehandling is large. There is considerable loss through rotting. When the raw material is an expensive material, such as rags, provision for tak-

(Continued on page 34)

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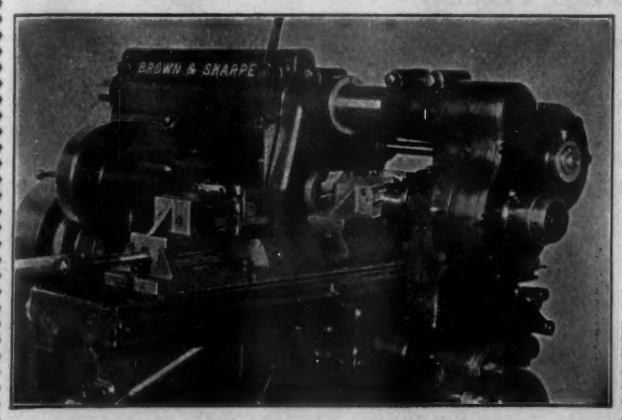

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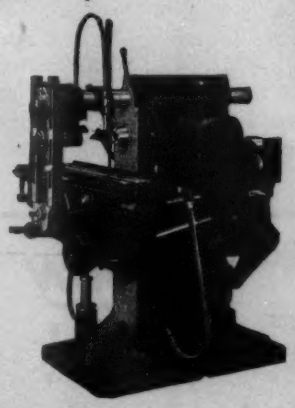

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Where dependability is vital

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Departmental Notes

(Continued from page 20)

In this way constant frequency may be manually maintained.

The driving motors for the substation generating equipment, sine-wave set excepted, are 2300-volt, three-phase motors. The motor power comes directly from the power house over the 2300-volt line. This high voltage is applied to the various substation motors through the medium of electrically operated oil switches. These switches are provided with mechanical interlocks so that all switches belonging to a single machine can be operated only in proper sequence. Red and green lights mounted on the face of the switchboard signal the on and off positions respectively of the oil switches. An inspection of this substation is well worth a half hour's time required. Any of the laboratory staff will be found willing to escort students on such an inspection trip.

For measuring purposes instruments of all types are necessary. The instrument room, at the west end of the laboratory, contains some 600 portable measuring instruments. This room is in charge of an attendant who is on duty from nine A.M. until six P.M.

The laboratory owns oscillographs capable of doing most excellent and accurate visual or photographic recording of occurrences in electric circuits. On account of the photographic work which goes on in conjunction with oscillographs an excellent dark room completely stocked with chemicals and accessories for photographic work is a part of this laboratory, this being one of four such dark rooms in the department suite. This is very essential because oscillographic work often requires the immediate development of a film before more pictures are taken. In this way the proper functioning of the many delicate contacts of the oscillograph may be checked without a serious loss of time or films.

The actual student experimentation is carried out as follows: Students are grouped in pairs according to their own desires. This grouping is necessary from the nature of the work, which requires much manipulation and the simultaneous reading of several instruments. In general before a student is allowed to start actual experimentation he prepares a preliminary report which explains completely what data he intends to secure and in detail how he will secure it. This report is submitted to an Instructor who corrects it and by conference with the student puts him in position to know exactly what he is to do. After the data has been secured the student writes a final report in which are submitted the results required in the experiment accompanied by a very thorough and complete discussion of the theoretical and operating characteristics of the particular machine under test. This final report is corrected and returned to the student who in general goes to his Instructor for further conference at which time vague and incorrect ideas are straightened out. With the honor groups, which have been set up amongst electrical engineering students, this procedure is altered by putting the individuals fully on their own responsibility during the term.

The wealth of laboratory equipment means that a great deal of repair work is continually carried on. The shop equipment includes lathes, drill press, milling cutter, shaper, grinder, forge, wood working machinery, etc. The shop personnel consists of five men who are kept constantly busy with the work of all the laboratories of the department.

The thesis work in the Electrical Engineering Department calls for a great deal of machine work on the part of the students, and a well equipped shop is reserved for student work only. Students working in this shop secure tools and supervision from the main shop of the department. These two shops are adjacent to one another for the convenience of all concerned.

Technology, through the Electrical Engineering Department, is a pioneer in the application of sectionalizing students according to their activity of mind. The next article of the series will therefore be devoted to presenting the factors which urged such sectionalizing and a discussion of the ultimate goal to be reached by such an educational system. E. G. BANGRATZ

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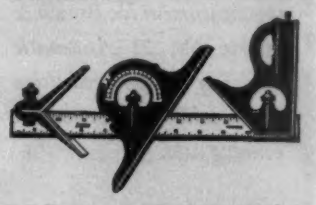

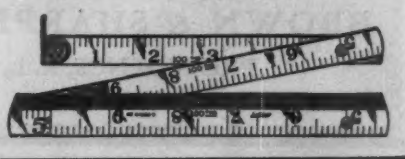

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Industrial Applications of the Spectrograph

(Continued from page 7)

and papers may have their sensitivity to various parts of the spectrum measured by using them as a sensitive material in the spectrograph, and allowing the light for which the measurement is required to fall on the slit of the instrument.

Textiles

Calico printers could use this instrument to identify and control their mordants, which are usually metallic salts. The silk industry could surely employ it for controlling the dressings used to increase the weight and lustre of their products.

All of the above applications have depended upon emission spectra, but following are some possible industrial uses of the spectrograph which depend upon the measurement of absorption spectra.

Alkaloids and Pharmaceuticals may be identified, and above all a strict control of their purity maintained, which is of the greatest importance to the medical profession and insures the public against toxic adulterants. The raw materials of these industries should be similarly tested. Toxicologists can use the method for identifying alkaloids or other poisons in a post mortem examination for amounts as small as 1/20 milligram.

The dye industry can standardize its products by determining the exact characteristic curve for each dye made, and testing every batch to see whether it is up to standard both as regards strength and purity.

Glass is now used for many purposes where an exact knowledge of its transparency for light of the shorter wavelength is essential. Thus Crooke's glass cuts off all the ultra-violet, while Chance's nickel glass allows a lot of ultra-violet to pass, and absorbs all the visible except a little in the red. Recently the Corning Glass Works have prepared a product which is said to be transparent throughout the entire spectrum (to 2100 A). Coloured glasses when used for railway and other signalling purposes should be accurately standardised with a spectrograph to prevent accidents through variations of tint.

Explosives. It is of interest to determine quantitatively the amount of nitrogen peroxide present in the gaseous products of combustion from a known weight of explosive. Nitrogen peroxide has a very characteristic line absorption spectrum, the number of lines varying with the concentration, so the spectrograph can be used to make a rapid analysis of the gases.

Liquified gases are becoming more and more important in industrial operations. Many serious accidents have occurred through impurities being present in them, but such risks can be eliminated by a rigid control of the substances by examining their absorption spectra, in which impurities would at once become apparent.

We have mentioned only a few of the possible applications of the spectrograph to industry. There are many others which would suggest themselves to specialists in the various branches of industry if they were acquainted with the possibilities of the spectrographic examination of their raw materials, intermediates and final merchandise.

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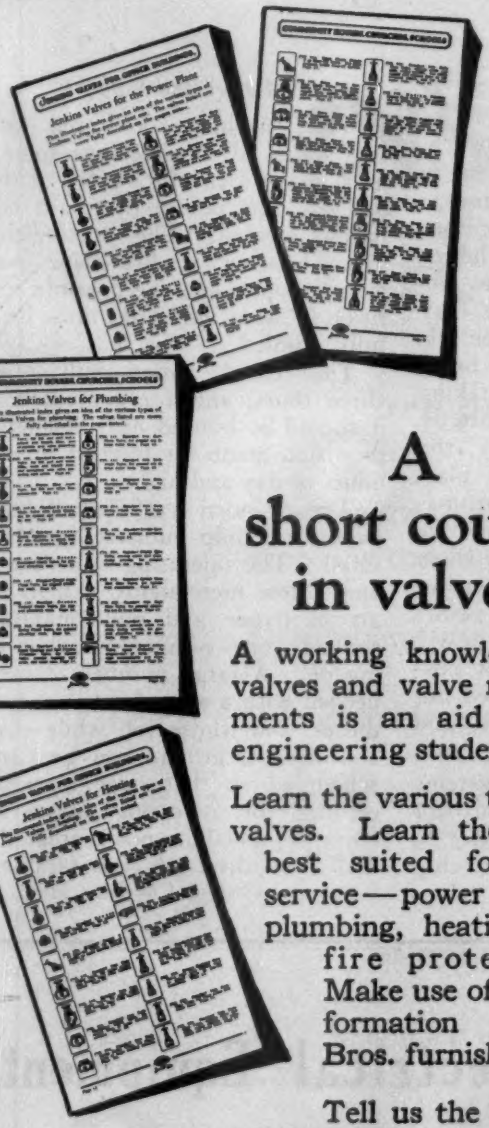
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Paper Mill Engineering

(Continued from page 28)

ing care of this must be in buildings under cover.

Possible exits of raw material to sewers must be guarded by "save-alls" (rotary screens and settlers).

Transportation and Handling

For a 100-ton mill in and out, 14 cars of wood may be expected, 5 or 6 cars of finished material, 6 to 10 cars of coal, and several others of miscellaneous supplies, new machinery, construction materials, etc. Also, under certain conditions it is necessary to haul away ash to the extent of 15 to 20% of the coal. Unfortunately these materials will not be delivered at a uniform rate, at times, perhaps, the cars of wood running up to 50 per day, which makes necessary a considerable acreage devoted to switching facilities and storage tracks. Perhaps there will be a locomotive crane. The switching may be done by line locomotives or pony engines, which might be oil fired or gasoline type.

One of the earliest problems, therefore, to be studied over will be the yard layout, combinations of trestles, curves, switches, so as to make as many of the buildings accessible as possible by standard gauge track, keeping elevations right for discharge of coal, wood, lime, etc., to storage places in the easiest way. Facilities must be provided for getting heavy machinery from the cars into its proper place, at the same time easy internal transportation must be allowed for, the two requirements being in some opposition, the first making the cutting up of the building site by standard gauge tracks necessary, the other calling for continuity of platforms, etc. Many times repair material must be transported from one part of the plant to another when switching would be both expensive and almost prohibitive. This points towards working floors on as nearly one level as possible; when not possible, ramps should be arranged for the operation of power trucks, and elevators are needed in extreme cases.

In the woodyard elaborate systems of conveyors must be laid out for getting logs first into piles, thence to the chip house, and from the chip house to the digesters.

Labor and Upkeep

While usually considered outside the realm of engineering, some one must make a careful survey of the labor situation before the plant is definitely located. The possibilities of local housing, a first-class potable water supply, and the possible competition of other industries must be carefully studied.

The usual paper mill operates three tours, and for contented labor it should be housed near the mill and provision made for food at almost all hours of day and night.

The proportion of skilled labor in paper and pulp industry is relatively small. The operating units are large and a few men highly skilled in the art of paper and pulp making can control quite completely what is going on. A large number of men are needed with a sort of rough inspection duties, and whose job while covering considerable ground can be carefully scheduled so that once learned, excepting for reporting of variations from the schedule, not a great deal of skill is required. A considerable force

(Continued on page 36)

The Tech Engineering News

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Paper Mill Engineering

(Continued from page 34)

is required of rather rough mechanics more in the line of millwrights. Unfortunately, rather more of these are used than would be best for the industry. A somewhat higher class of mechanics working under technical direction would many times be more profitable than the method of handling maintenance work that has become standard usage. A small amount of common labor is required for assisting in maintenance work, handling supplies and raw material, and output where machine transportation is inadequate.

Fuel and Power

Machinery and devices used should be adapted to the class of labor available at mill location. At present in this country the cost of heat and power amounts to from 10 to 25% of the total cost of the product. The two items are so intimately interlocked that any one attempting to handle them separately will run into endless difficulties and add very much to his manufacturing cost. Saving in fuel and labor through the proper handling of heat and power offers one of the most fertile fields for engineering in the industry at the present time. Every pound of paper requires from three to five pounds of steam for its proper drying. Every ton of pulp requires 4,000 to 5,000 gallons of hot wash water at 200°. Some 15,000 to 20,000 gallons of water are required per ton of pulp in the case of soda or sulphate mill at the evaporator condenser. Every kilowatt hour required from condensing units manufactures 50 to 70 gallons of warm water. Some 50 to 100 kilowatt hours are required per ton of pulp. One-quarter to one-half ton of coal is required for each ton of lime reclaimed. 3,000 to 6,000 pounds of steam are required in cooking each ton of pulp. Waste products are produced in some forms of pulp manufactured which at the present day are largely thrown away but have in a dry state an evaporative value of 12,000 B. t. u. per pound.

Fundamentally, to make the best use of fuel we must let down from our combustion temperature of 2500 to 3000°F. as slowly as possible, accounting for every B. t. u. As examples, we perhaps produce steam in the boilers at 400 lbs. pressure, and superheated to 650°F. temperature. We use the waste heat gases first to heat boiler feed water in the economizer, then preheat air for combustion or perhaps used in a coal dryer. The next drop in temperature from 650°F. is down to 100-125 pressure and 370°F. via a high back-pressure turbine serving as reducing valve for steam to digesters; also, part of the steam at 650° will go to a turbine exhausting at 15 lbs. into the dryers of the paper machine. This might be a bleeder and at a lower stage steam would be taken off at about atmospheric pressure for heating the high-temperature wash-water desired. We would endeavor to step the heat down from the digester by utilizing the steam from the blow, and after the high-temperature wash-water has served its purpose we might circulate it through heat interchanger or mill pipes for heating a building or for furnishing a lower temperature wash-water at, say, 120°.

After the steam that is used in the dryers has served its purpose, we could use the vapor driven off of the paper to heat the mill buildings.

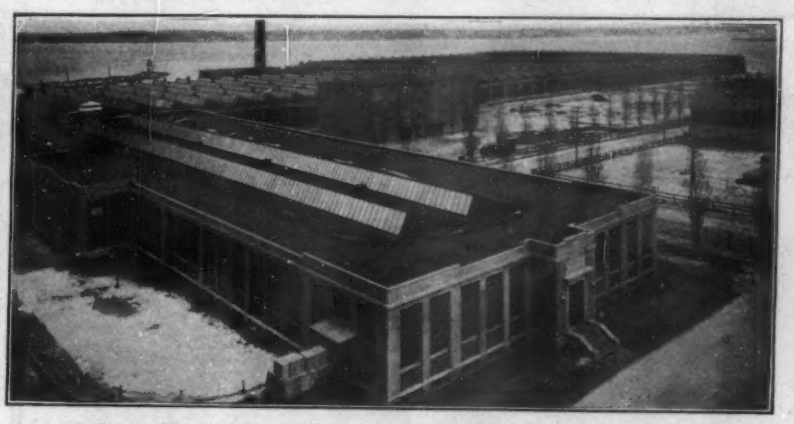
In addition to heat used about as indicated, we have heat generated by sulphur burners in the sulphite process, the heat generated in the black liquor burners in the soda and sulphate process, the heat generated in connection with the recovery of lime. Several of these processes are susceptible of producing considerable steam when waste heat boilers are properly applied; in fact, there is said to be abroad a mill which is able to produce all the steam required through utilization of the heat available from waste products.

First Cost

In most cases there is nothing more expensive than a plant where quality, workmanship, and space is skimped in order to reduce first cost. Such a procedure requires later constant repair work, and production is perpetually handicapped because of cramped quarters, unstable foundations, etc. On the other hand, the plant may be easily handicapped by over-sized structures, timidity in the use of construction materials, foundations too large and too expensive, and a blind following of precedent in design.

Paper and pulp mill structures are of little use for anything else, excepting for the purpose designed; in fact, they become part of one big machine, and the designer should bear this in mind at all times. Factors of safety used should be at all times adapted to the anticipated loads without much regard to the fact that the building will ever be used for anything else than its present purpose. Paper and pulp mill structures and piping are subject to much corrosion and rust, and wooden structures to rot. There-

(Continued on page 38)



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	Smoky City	*Smokeless City*
Galvanized Sheet Iron	*3 to 6 years*	*7 to 14 years*
Galvanized Sheet Steel	*3 to 4 years*	*5 to 10 years*
Tin Sheet Iron	*13 to 15 years*	*18 to 20 years*
Tin Sheet Steel	*6 to 10 years*	*10 years*
Copper	*10 to 20 years*	*No limit*

Where there is smoke, there is destruction—destruction of building, machinery and finished product. And even worse is the impairment of employes' health and efficiency.

Not alone as a civic duty, but equally as a matter of plain commercial profit, your plant should be a leader in the "Smokeless Town" movement. Send today for our interesting book, "Gas—The Ideal Factory Fuel".

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YOU CAN DO IT BETTER WITH GAS

Paper Mill Engineering

(Continued from page 36)

fore, where it is impossible to protect against such deterioration ample allowance should be made in preparing sizes. Changes in the art are many. A design for a life of over twenty to twenty-five years is useless.

Concrete and structural steel, with brick used as filling in, has come to be almost exclusively the present construction, wood still being used on roofs and some of the lighter members. Steel sash is used quite commonly, its maintenance being high where soda and acid dust or fumes are in the air.

The heating problem of a pulp mill is small, generally moist warm air and considerable machine friction and process radiation taking care of a large part of the requirements. There should, however, in northern climates be enough of heating coils to prevent freezing of material in pipes. In the paper mill the problem of ventilation and heat is a very large one and generally the two have not been well worked out together. The present adoption of closed-in machines with make-up hot air is helping out very materially on the whole heat and ventilation problem.

Inasmuch as a plant runs for 24 hours, and on the average only half of this time is there outside light, the question of proper artificial lighting is worthy of closest study. In fact, while daylight lighting is desirable its weight as an influence on design is not as great as in single-tour industries.

Quality of Product

Excepting that of textiles, there is no prominent industry wherein a small amount of dirt can play as much havoc with quality as will dirt in a plant manufacturing white papers. The choice of raw material is rather limited, the raw material under-goes a successive degradation in length of fibre, and in its handlings the utmost care must be taken to prevent the introduction of anything excepting the materials required. For this reason expensive piping like copper must be used many times when iron piping might ordinarily serve. Tanks and vats must be tiled and brick-lined. Facilities for inspecting quality must be employed so that the source of any defect arising can be instantly located. The handling of pulp and paper problems is in quite a different class from machine handling problems because of the changes taking place where they cannot be seen and because after all the chemistry and physics of the industry is not well developed. A plant designer therefore cannot depart from tried lines in a very broad way.

In outlining engineering requirements in the design of successful paper manufacturing enterprise little mention has been made of anything but practices quite well standardized. Due largely to diminishing raw material supply and substitution of woods not previously considered acceptable for paper-making, new methods of preparing, cooking, bleaching, beating and drying are in processes of development. Many of these new processes apparently possess much merit. The engineer will find the choice of a wise design from among all those processes very far from an easy one.

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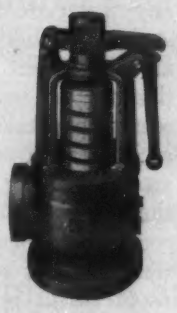

Forms DI & DS

Consolidated Safety Valves Form DI, Iron Body, and Form DS, Steel Body, are good for pressures up to 300 lb. on saturated steam; and 350 lb. on saturated or superheated steam respectively. They are designed to meet the requirements of the A. S. M. E. code, have a large relieving capacity, and will act with a sharp positive action when the pressure reaches the point at which they are set to relieve. Other Forms are made for pressures up to 1500 lb.

Hancock Valves

Bronze Valve

Hancock Valves are made for all pressures, they are made of either Bronze, Cast Steel, or Forged Steel. For temperatures over 450° F Steel Valves should be used. Hancock Valves are made to withstand hard usage and the hardest service in a power plant. When the proper valve is used for a certain condition it will stay tight and give satisfactory service for a long period without any attention.

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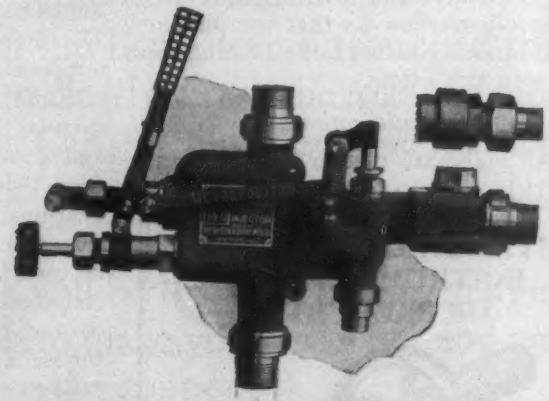

Double Tube Injector Model O

Metropolitan Injectors are made with either single or double tubes. The single tube Model N, is automatic in that it will restart automatically if either the steam or water supply is interrupted. This injector is very efficient on low pressure and portable boilers. The double tube Injector Model O is good for all pressures from 35 to 350 lbs. It will take water under a head or lift it from a well and will work with hotter feed water than most other injectors.

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Metropolitan Injectors
Boston, Mass.

Problems of Steam Turbine Design

(Continued from page 13)

er until proper alignment has been secured.

In order to maintain the axial position of the turbine spindle, a special thrust bearing of the Kingsbury type is generally used. A section through this type of thrust bearing with its adjusting gear is shown in Figure 2. The thrust bearing is mounted in the high pressure end of the cylinder and is provided with an accurate gear for its adjustment as it is necessary to maintain an accurate axial clearance in the various parts of the turbine unit. This thrust adjusting gear is provided with a positive means for locking same in a fixed position when it is once set. It is also constructed with positive stops so that the thrust bearing can be moved in either direction only a certain fixed amount, thereby preventing contacts between the rotating and stationary parts should any one accidently move the thrust bearing in the wrong direction.

The lubrication of the thrust bearing is positive and is arranged with a sight oil overflow so that the amount of oil passing through the bearing can be seen at all time.

Lubrication

An elaborate system for the circulation of the oil to the various parts requiring lubrication is provided on all turbo-generating units. This system requires, first, an oil tank of ample capacity for the oil to come to a complete rest in order that same may be freed of air collected during the circulation of the oil and also to allow any water or other foreign matter to settle to the bottom of the tank; second, an oil cooler of ample capacity, so that the oil may be cooled down to a reasonable temperature before being recirculated to the bearings; and third, an oil filtering system through which the oil is circulated for the purpose of removing moisture and other impurities collected so that the oil shall always be in proper condition for the most efficient lubrication.

Generally the capacity of the oil in the circulating system is 10 times the amount circulated per minute. The temperature at which the oil may be allowed to enter the bearings depends somewhat on the quality of the oil. The lighter the oil, the lower the temperature should be in order to obtain the best results. Certain parts, such as gears driving the oil pumps and governors, require a heavier oil than that required for lubrication of bearings; consequently it is well to remember that while a light oil may be used for lubrication of the bearings, consideration should always be given to the question whether this oil at the same time will be suitable for lubricating the gears driving oil pumps and governors.

Auxiliary pumps are always provided on each turbo-generating unit in order to take care of the lubrication of the various parts during the starting and stopping of the turbine unit and also in case of an emergency such as trouble with the main oil pumps. Generally, these auxiliary oil pumps are equipped with automatic starting devices so that same will automatically go into service in case the main oil pump should break down.

Higher Temperature Development

In practically all papers on steam power plants, the possibilities of raising the temperature of the steam is discussed in considerable detail. Undoubtedly, this is a development that offers the greatest possibilities for improving the efficiency and at the same time simplifying the construction of the complete power plant. Power plants using the reheat cycle where the steam, after having expanded to a certain point, is reheated and then allowed to complete the expansion, are quite complicated with special equipment such as superheaters with all the piping and valves, and also special construction in the turbine unit itself. It is clear, therefore, that if we could use a higher temperature corresponding to the most economical pressure and then construct a straight expansion turbine, a considerable simplification could be made in the power plant equipment, resulting in less complication in operation and an increase in the efficiencies in the power plant. It is no wonder, therefore, that the possibilities along these lines have a tremendous fascination for all Engineers engaged in power plant design.

In order to explain more in detail the possibilities along these lines, a Mollier diagram, Figure 2, in the Author's paper entitled "A Review of Steam Turbine Developments", presented at the Spring meeting of the A. S. M. E. in 1925, is reproduced herewith in Figure 3. A new expansion line "W" has been drawn showing the steam expansion through a turbine for steam condition of 1200 lb. pressure, 1000°F. temperature and 29" vacuum. It will be noted that the expansion curve will end at almost the same point in the exhaust as expan-

(Continued on page 42)

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(Continued from page 9)

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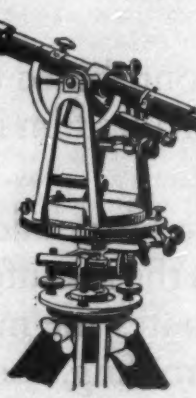
A Civic Service number of *The Tech Engineering News* will be published next month. It will contain leading articles in this field.



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Turbine Design

(Continued from page 40)

sion line "D" on diagram, on page 13, which represents the expansion line through a steam turbine for steam conditions of 1200 lbs., 725°F. temperature expanding to 350 lbs. and then reheated to 700°F. and then expanded to 29" vacuum (as at Edgar station of Boston Edison Electric Co.). Checking over the actual figures for these expansion lines, it will be found that a material increase in the available energy will result from the increased temperature and, of course, with the same turbine efficiency a material increase in power plant efficiency will be made.

While the final results can be readily pictured so far as economy is concerned, there are certain mechanical problems to be solved both in construction and in the obtaining of suitable materials which can be accomplished only through experiments and research work. However, work of this nature is carried on all over the World and, undoubtedly, it will be only a matter of a comparatively short time before we shall see power plants operating under the conditions mentioned above. Whether it will be profitable to go to still higher pressures is very questionable unless at the same time we can make a corresponding increase in temperature.

Among the materials so far produced, a certain grade of chrome nickel steel seems to offer the best possibilities for the construction of equipment suitable for this higher temperature. Of course, it is realized that the design of the various parts must be modified so as to assist in the use of this material. It will also be necessary to develop new construction methods for the manufacture of certain detail parts which up to the present has not been possible. However, the indication is that we shall see considerable new development along the line of increasing temperatures in steam power plants within the near future.

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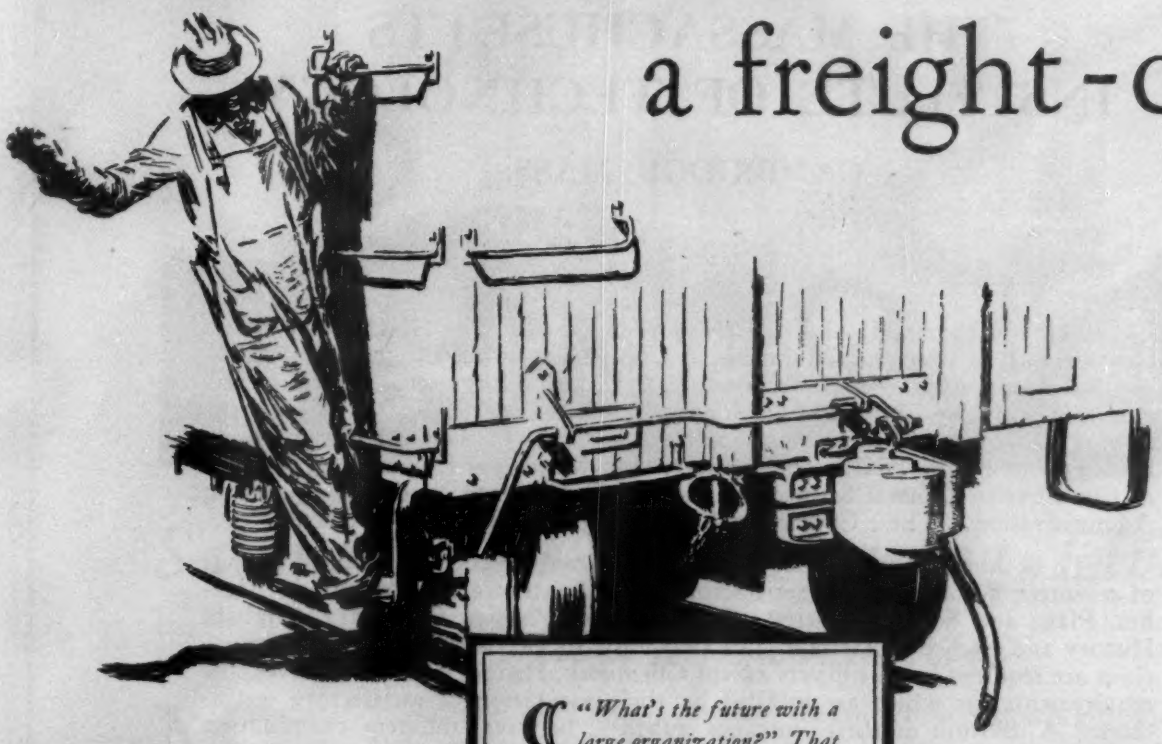

"What's the future with a large organization?" That is what college men want to know first of all. That question is best answered by the accomplishments of others with similar training and like opportunities. This is one of a series of advertisements portraying the progress at Westinghouse of college graduates, off the campus some five—eight—ten years.

CORLISS A. BERCAW

WHEN Corliss A. Bercaw went down to the tracks to get facts for his thesis in 1918, he was only following a lifelong habit.

From the time he was old enough to delight in the shrill whistle of a locomotive, through his student days at California Institute of Technology, the most fascinating thing in the world to him was a railroad train.

It isn't just happy chance that, at 29, he is a Sales Engineer in the Transportation Division of the Westinghouse Company, at Philadelphia. And it was quite natural that Bercaw should have an important share in the negotiations involving one of the most revolutionary transportation developments of the century—the development of the gas-electric rail car.

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But to perfect this new car required thorough cooperation between the Westinghouse and Brill Companies, whose engineers supplied, respectively, the electric generator and gas engine which, combined, give this car its practical advantages. Bercaw acted as liaison man during this development stage, and now he is engaged in selling, among other things, these cars, representing the newest idea in railroad transportation.

When Bercaw entered the Graduate Students' Course at East Pittsburgh in May, 1919, he was fresh from college—and naval aviation. His enthusiasm for railroading was not allowed to cool—he wasn't shunted into unfamiliar lines. For thirteen months he was a student in the Railway Shops. Then for six months in the General Engineering Department he learned how to apply Westinghouse Equipment to railroad needs. It was a logical step next to the Heavy Traction Division of the Sales Department at East Pittsburgh. And two and a half years there landed him in his important work in Philadelphia.

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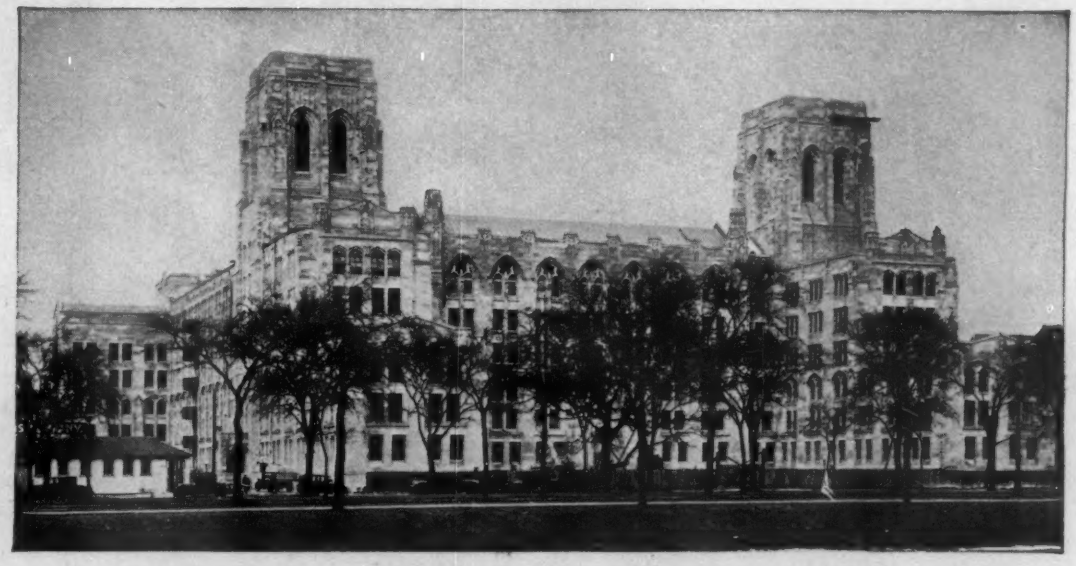

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The latest development of Otis Collective Automatic Control permits of the use of automatic push button elevators in the highest class and size of hospitals, where heretofore the automatic type was limited to low buildings where the elevator service was infrequent.

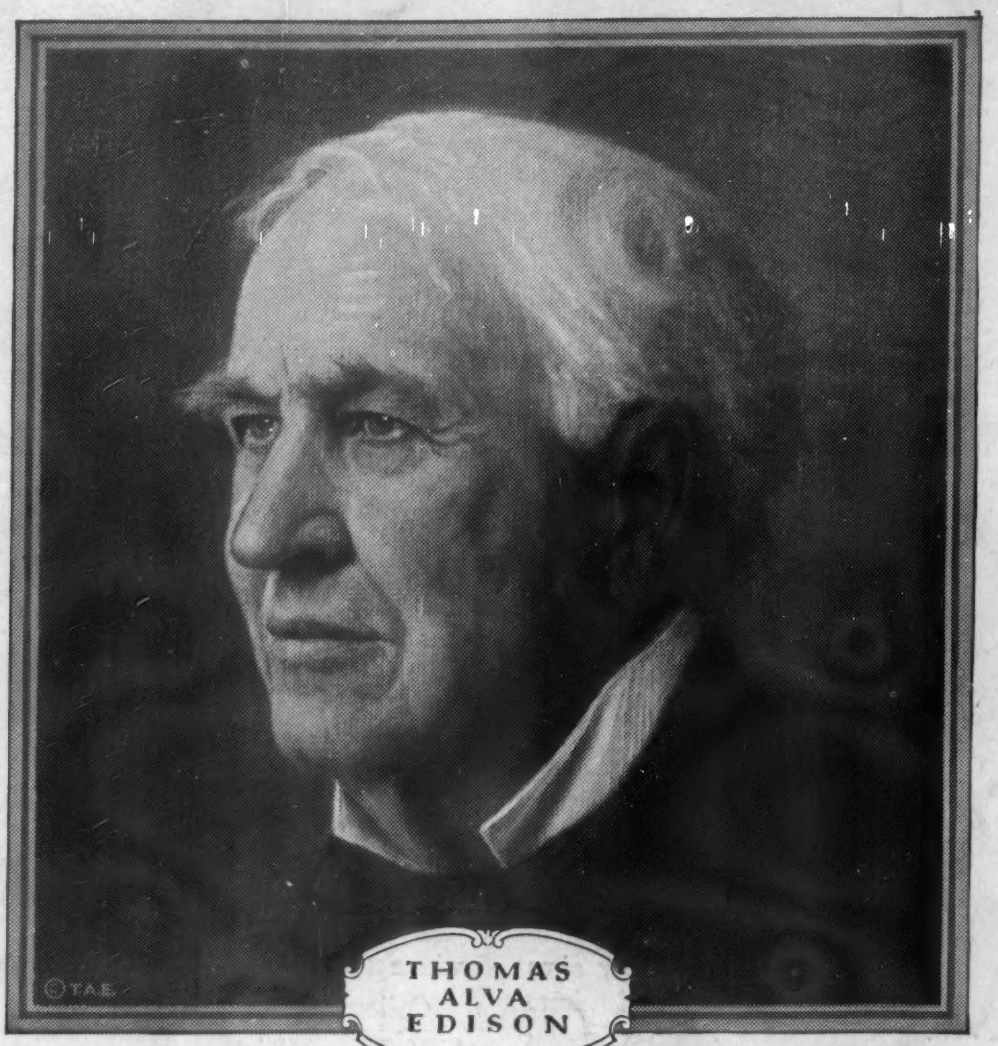
Collective Control is so arranged that the elevator automatically answers all the calls in the direction in which it is traveling, and does not require any operator. It also stops on any trip at all floors for which a button in the car has been pressed, the older system of control necessitating the elevator answering only one call at a time.

It is significant that the Medical Buildings of the University of Chicago, pictured above, as well as the St. Luke's Hospitals in Chicago and Cleveland are installing Otis Collective Control Push Button Elevators, representing the last word in hospital elevator operation.

THE WORLD'S WORD FOR ELEVATOR SAFETY

OTIS ELEVATOR COMPANY

Offices in all Principal Cities of the World



HIS FAITH unconquerable, his passion for work irresistible, his accomplishment not surpassed in the annals of invention, Thomas Alva Edison has achieved far more than mankind can ever appreciate. February eleventh is the eightieth anniversary of his birth.

Wherever electricity is used—in homes, in business, in industry—there are hearts that are consciously grateful, that humbly pay him homage.

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